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ELECTRIC BELL FITTING

F. C. ALLSOP

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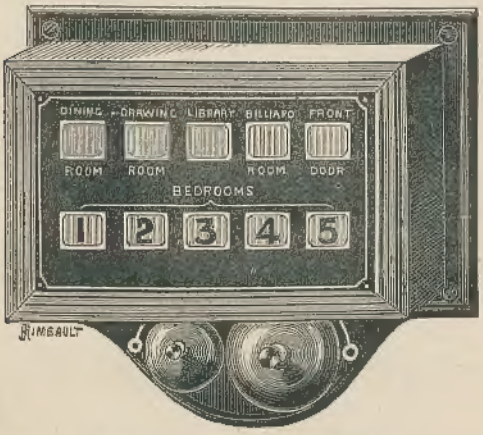

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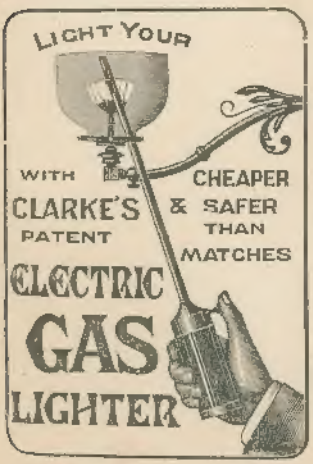

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ELECTRIC BELL FITTING:

A TREATISE ON

THE FITTING-UP AND MAINTENANCE OF ELECTRIC BELLS

AND ALL THE NECESSARY APPARATUS.

BY

F. C. ALLSOP.

WITH NEARLY 150 ILLUSTRATIONS.

E. & F. N. SPON, 125, STRAND, LONDON.

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1889.

PREFACE.

THE favourable reception accorded these articles when they originally appeared, some eighteen months ago, in the 'English Mechanic' has induced the author to reissue them in book form. They have been thoroughly revised and enlarged, much of the additional matter being suggested to the author by the numerous questions addressed to him on the subject of electric bell fitting in the query columns of that journal.

Knowing the want that is felt of practical information on this subject, it has been the aim of the author to deal with it in an explicit and thoroughly exhaustive manner, and to lay before the fitter the "why and wherefore" of electric bell fitting in a way that he feels sure will be most readily understood.

The author desires to express his thanks to the following firms for the use of some of the cuts contained herein: to Messrs. Binswanger (of the General Electric Apparatus Co), Messrs. Woodhouse and Rawson, Messrs. Jensen, The Telegraph Manufacturing Co, The Walsall Electrical Co., Messrs. Mayfield, Cobb & Co., Gent, Judson, and Thorpe.

F. C. ALLSOP.

37, NORFOLK STREET, STRAND, W.C.

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PRACTICAL

ELECTRIC BELL FITTING.

CHAPTER I.

WIRING, SOLDERING AND JOINING WIRES, AND EARTH CONNECTIONS.

The great and increasing demand for electric bells in this country has been productive of a vast improvement, not only in the bells themselves, but in all the apparatus appertaining to them. Keen competition has, on the other hand, resulted in the placing in the market of inferior bells, indicators, and pushes chiefly of foreign make—which are altogether of an unsatisfactory nature. These are generally fixed in conjunction with a system of cheap and inferior wiring, and, when so fixed, have resulted in nothing but universal dissatisfaction.

Greater evils, however, result from inferior wiring than from cheap and inferior bells and indicators, as these are at all times accessible, while renewing the wires after a building has been completed and finished can only be done at great expense and trouble; and the use of bad wire cannot but be prejudicial to both buyer and seller. It may be urged that the size of wire herein mentioned is rather large and expensive; but the author is sure that the slight extra expense entailed by its employment will be fully repaid by its greatly increased durability, and the immunity from repeated breakdowns in the communication from the failure of a bad wire.

For indoor work, &c., No. 18 B.W.G. copper wire, covered

with guttapercha and with a final covering of cotton wound round and round, making in all a total thickness of No. 10 B.W.G., should be used. This should be obtained in two different colours, all the return wires from the pushes being kept of one colour, and the outgoing of the other. This should be strictly adhered to, as it greatly facilitates matters in first laying the wires, and, should a fault subsequently occur in any of the wires, the faulty wire having been found at one place, there is no difficulty in identifying it at either the push or battery end. For outdoor work or exposed places the wire which is used in telephony for the "leading in wires" will be found the most suitable; these wires generally consist of No. 18 B.W.G. copper wires covered with two coatings of guttapercha to a total thickness of No. 10 B.W.G., tightly wound with tape, and lastly, well covered with Stockholm tar. When the wires are situated in places where the atmosphere is subject to much variation, such as being alternately dry and damp, it will be found advantageous to employ wires insulated with indiarubber in preference to those covered with guttapercha, as under these conditions the guttapercha is liable to crack, and the wiring will show at times excessively low insulation. In very dry situations a class of wire known as paraffin may be used. The insulation of this wire consists of a number of longitudinal strands of cotton, followed by other strands wound round and round the longitudinal ones, the whole being afterwards immersed in melted paraffin wax, and polished by friction. These wires are also to be obtained with the outer covering of cotton, instead of being simply wound round the wire, plaited round it. Wire thus treated is known as "braided," and, though rather dearer in price, is to be preferred, as the ends, when stripped, have no tendency to unravel, a great fault of the ordinary paraffin wire. Owing to the variety of colours and patterns in which it can be obtained, paraffin wire is very suitable for running round skirting and places where it is exposed to view. A great saving of time and trouble can be effected by using wire that is "tinned,"

i. e. has been coated with a thin layer of tin previously to being insulated. The use of tinned wire greatly facilitates getting good joints, and the ends, when stripped for placing under the binding screws, do not oxidise like the plain copper.

For all *ordinary* work the fitter is strongly advised never to employ a wire of smaller gauge than that mentioned above, as the smaller size wires, such as No. 20 or 22, that are sometimes employed, are but ill-fitted to withstand the rough usage to which they are so frequently treated when being drawn through the tubes, or, if stapled round the skirting, to the accidental knocks and injury to which they must necessarily be subjected. There are instances, however, where the employment of a smaller gauge wire is not objectionable, and, indeed, often advisable in the case of a large Hotel or other building where the number of wires employed is very great, and where the wires, in preference to being put in tubes, should be run in a special wood casing. Here the wires can be laid in the casing without being subjected to any strain, and the lid being removed, they can easily be got at for inspection. Owing to the number of wires, it is important that the gauge of the wires should be reduced as much as possible, in order to bring the casing down to a convenient size; so it is preferable to employ a smaller size wire, No. 20 or even No. 22 being used for this purpose. The resistance of the circuits will, of course, be higher than if No. 18 had been used, but the cost of the addition of a few more cells to the battery is but a small portion of what the extra expense of wiring the building with No. 18 would be.

Sometimes, with a view to economy, the "main" wire, i. e. the wire that runs from one pole of the battery to one of the springs of all the pushes, is heavily insulated, and the "line," or remainder of the wires, covered with a second-rate insulation. But this method is not advocated, it being the cheapest in the end to insulate all the wires equally well. For although no leakage takes place from pole to pole of the battery, owing to the main wire being well insulated and ending at the

pushes, yet, after a time, leakage takes place between the line wires themselves, causing, when a push is pressed, two or three shutters of the indicator to fall in addition to the right one.

In fixing the wires the method employed will, to a certain extent, vary to suit the particular requirements of each case. In a new building the wiring should be commenced as soon as the bare walls are up and the roof on. In this case the wires should be placed in light zinc tubes, and the tubes nailed to the walls with stout 2 inch floor brads. As the walls would not at this stage be plastered, an uninterrupted run can be secured from the top to the bottom. Care must be taken, in sliding these tubes over the wire, not to abrade the insulation, and never put more wires in one tube than will slide through *easily*.

When wires are run in tubes there are two methods that may be adopted: (1st) the wires and tubes may be fixed at the same time, or (2nd) the tubes may first be nailed to the walls, and the wires drawn in afterwards. The first is without doubt the best and most expeditious method The objection generally urged against it is that the plaster being put on after the tubes are fixed, the damp during the drying of the walls passes into the tubes and affects the insulation of the wires. No doubt during the drying of the walls some moisture does collect in the tubes, but it soon dries out, and if the size wire advocated here is used, the moisture is not in the tubes long enough to do any harm.

In the second method, however, it is never possible to get straight runs for the tubes, and unless the tubes are *very carefully* fixed, some abrasion of the wires is sure to take place when they are being drawn in, which sooner or later develops into a serious fault In putting in wires by the first method, the wire is first cut off the right length, and the different lengths of tube slipped over and nailed up to the wall, one length of tube being fixed before the next length is put on. In the second method, the tubes having been fixed and the plastering done, a bare copper wire is passed through the tube from the top to the bottom. At the bottom is an assistant waiting to

receive the end of the wire, which he fastens to the end of a coil of insulated wire that he has by the side of him. He then gives a signal, and the wire is drawn through the tube, the assistant carefully guiding the wire into the tube, and preventing the wire getting into kinks.

In joining the lengths of tube, the end of the one should be slidden over the other for about an inch or so. To do this, open the end of the length of tube which you are going to add, with the pliers, so that it will pass over the next, bend the edge of the inner one slightly outwards, and then slide the other length over it, as shown in Fig. 1, this will prevent any abrasion of the insulation, should it be necessary to pull a new wire through at any future time. Try to get as straight a run for the tubes as possible, so as to facilitate renewing a wire should it be absolutely necessary.

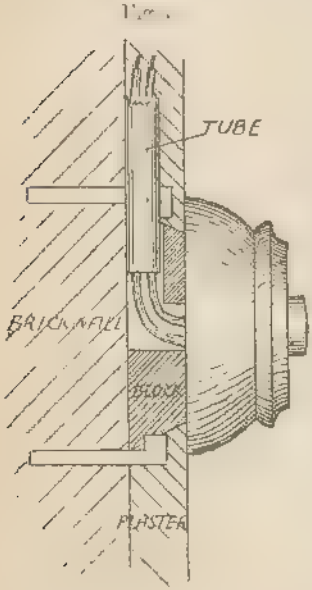
Fig 1

The position of the pushes should be determined as early as possible, so that the blocks to which they are to be fixed can be put in their places. When the position has been determined, which is generally not until the plastering is done and the chimney-piece fixed, the plaster must be cut away to permit a round, levelled wood block (shown in perspective in Fig. 2 and in section in Fig. 3), being nailed with two or three floor brads to the brickwork. This block, made preferably in elm, is 3 inches at its greater, and 2½ inches at its lesser diameter, and of such thickness that when it is fixed its face comes flush with the surface of the plaster. As will be seen from Fig. 3, there is a groove cut from one side to the centre, so as to allow the tube carrying the wires to enter a little way. In rooms where there are two pushes, one on each side of the fireplace, it is preferable to take the tubes carrying the wires

Fig 2

round over the mantelpiece, instead of going round or under the hearthstone.

If the building to be wired is in a finished state, the above method cannot, of course, be adopted. In this case the wires should be run round the skirting board and under the floors, fixing the wire with small staples. Do not, however, drive a staple so far as to injure the insulation, and *never* put *two wires* under *one staple*, or allow two staples to touch one another. All staples, especially those used for outdoor work or in exposed places, should be well galvanised or coppered. If the sight of the wires is objected to, a light ornamental casing to match the skirting may be employed to contain the wires in such places as they are exposed to view; this will also serve to protect the wires from mechanical injury.



Where wires are run under the floors in the same direction as the boards, they should be placed in small notches cut in the top of the joist, ½ inch apart, in the centre of the floor board. If the wires are placed near the edge, they are liable to be injured in screwing down the board. If there are many wires, the practice of notching the joist is not advocated, as it weakens the joist. A better plan is to bore a hole for each wire about 2 inches from the top of the joist, as this practically does not weaken them at all. When the boards are replaced, care should be taken to see that they are screwed, and not nailed, down, so as to allow of ready access.

In places where communication has to be extended to an outbuilding some distance off (such as from the house to the stables), a naked wire is taken overhead. For this purpose No. 16 B.W.G. hard-drawn copper wire should be employed, the wire being fixed on insulators either supported out from the walls by an iron bracket, or slung by means of 7–18 galvanised iron wire from the most accessible chimneystacks. The G.P. leading-in wire should be joined to the line wire at the last insulator, and passed down the side of the building into the interior through a hole that has been previously knocked through. The leading-in wire, before passing into the hole, should make a dip below and then bend up again, so as to cause any water running down to drip off at the bend. In some cases the use of overhead wires is objected to on account of their unsightliness. The wire (such as is advised for outdoor purposes) may then be placed in a small, creosoted wood casing, laid underground at about 10 inches or 12 inches from the surface. Such a casing is shown in Fig. 4. It can be constructed very cheaply, and is to be preferred to iron pipes in most instances, from its accessibility at all points. In going under roads, however, and ground where there is much traffic on the surface, iron piping should invariably be used, care being taken to get the joints perfectly watertight.

Fig. 4

Where an earth return is necessary, care should be taken to obtain a good connection. Some people seem to have an idea that any flimsy attachment, such as twisting a wire round the nearest gas bracket, is sufficient. This, though it may be simple, is by no means efficient, and as the wire rapidly oxidises, a break in the communication occurs a day or two after the apparatus is fixed. To make a good earth connection, the following plan should be adopted: Having selected the most accessible point in the nearest water main, and scraped the pipe clean for a length of about 3 inches, take a piece of

naked copper wire, No. 16 B.W.G., about 2 feet long, previously brightened with emery paper, and twist this tightly round the pipe, leaving a tail of about 6 inches; then solder the whole well together. Now run your earth wire, which should consist of No. 16 naked copper or 3 16 galvanised iron wire, twisting and soldering this to the projecting tail.

If this is properly done, an excellent and lasting earth connection will be secured. Great care should be taken to see that this is not a cistern pipe, for, if so, there will be a "bad earth," caused by the break in continuity at ball cock in the cistern.

Should there be no water main within reasonable distance, attach to the gas main, the street side of the meter (if on the house side the meter must be bridged over with a piece of wire), owing to the white and red lead used in the joints making a very bad electrical connection. Never, if it can possibly be avoided, have the earth connection on the water main at one end, and on the gas main at the other, as permanent currents are thereby often set up.

Should neither a water or gas main be obtainable, a pump pipe leading to a well makes a good "earth." Failing this, an artificial earth must be resorted to, which should be made thus: Suspend about 5 feet of sheet-lead 6 inches wide in the centre of a hole about 4 feet deep, then ram in with ordinary gas-coke till within 6 inches of surface, when fill in with soil. The earth wire must then be soldered to the projecting end of the lead. Care should be taken to obtain as moist a situation as possible for the hole.

Where wires are exposed to view, particular attention should be paid to the running of the wires so as to give them a neat appearance, as nothing forms a greater eyesore than carelessly run or improperly stapled wires.

We give below a list of the principal tools, &c., required in electric bell-work, both for indoor and outdoor circuits.

FOR INDOOR WORK:

2 long "bell" gimlets.
2 small gimlets.
2 wood chisels.
2 cold chisels.
1 pair of taper nose cutting pliers.
1 pair of round nose pliers.
1 long brick drill.
1 large hammer.
1 small hammer.
2 screwdrivers.
2 bradawls
1 keyhole saw.
1 file, 8-inch, half-round.
1 spirit lamp.
1 small soldering iron.
1 ratchet brace, with augers.
1 two-foot rule.
1 detector.
Emery cloth.
Chatterton's compound.
Sheet gutta-percha.

FOR OUTDOOR WORK. The following additional tools will be required:—

1 draw vice and key.
1 large pair of pliers.
1 12-inch half-round file.
1 firepot.
1 large soldering iron
Bag of charcoal
Portable battery, consisting of 3 smallest size Leclanché cells, fitted into a wooden box.

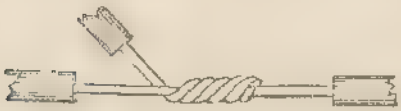
Too much importance cannot be attached to having good well-soldered joints. The practice of twisting up the joints without a scrap of solder, though it may expedite matters in laying the wires, is too frequently the cause of a gradual falling off in the ringing power of the bells, due to increased resistance being thrown into the circuit by the rapidly deteriorating joints; which falling off in the ringing is at once put down by the inexperienced fitter as due to the exhaustion of the battery.

To make a good joint, the following method of procedure should be adopted: Strip the ends of the wires to be joined of their insulation for a length of about 1½ inches, and scrape clean with a knife, or brighten with emery paper. Then (taking one wire in each hand), twist the wires together as shown in Figs. 5 and 6 (Fig. 6 is a branch wire), and tighten up with the pliers. Now get ready the articles required for

soldering, which should consist of the following. A small copper bit, made out of a piece of ½-inch copper rod 2 inches long, one end of which is filled with a convenient handle, and

Fig. 5

Fig. 6.



the other filed wedge-shape with an ⅛-inch groove cut across on face, as in Fig. 7; a small spirit-lamp for heating the bit, a stick of solder, and lastly, a piece of composite candle or rosin. The best "blowpipe" solder should be used, the quality of which may be tested by holding it up to the ear and

Fig. 7.

bending it, when, if it is good, a peculiar creaking noise will be heard which is known as the "cry of the tin." To solder the joint, heat the bit, previously turned, in the spirit lamp, and wipe with a piece of clean rag, and then, holding it with the grooved side upwards, fill the groove with solder. Now rub some composite candle or powdered rosin on the joint, and lay it in the groove, turning it over till the solder runs completely round, when quickly wipe with a piece of rag, and the result will be a strong, clean joint.

This method will, in most cases, be found the best for small wires, as the practice of using a big iron or blowpipe, unless

great care is taken, generally ends in either melting the insulation so that it runs on to the iron, entirely preventing good work, or else (especially with the blowpipe), in setting the insulation on fire on both sides of the joint. In soldering, never use *spirits*, as with the small wires here referred to the corrosion that takes place will (especially in damp places) rapidly eat the wire asunder. Care must be taken in stripping the insulation from a wire that the wire itself is not nicked, for if this is done it will readily break at this point if bent at any future time. The insulation should always be removed by drawing the blade of the knife parallel with the wire, and not by cutting through the insulation at right angles, as this will most certainly nick it.

All the joints, after having been soldered, must be thoroughly insulated. The importance of this is frequently overlooked, causing serious trouble afterwards, that might have been spared by a little attention in insulating the joints.

To insulate a joint, proceed thus. Place a piece of clear glue on the joint, and smooth over with a warm iron, joining it well with the insulation on each side; then bind the whole tightly round with indiarubber tape. Greater care must be taken when insulating a joint in wires laid underground, or in exposed places, three or four alternate layers of gutta-percha and tape being put on, and the whole covered with Stockholm tar. Making a good insulated joint, however, in an underground wire, that will show high insulation and stand for any length of time, is an art in which few attain perfection, without having had long and constant practice in such work.

CHAPTER II.

PUSHES, PULLS, CONTACTS, AND SWITCHES.

Pushes can now be obtained in almost every conceivable design and shape, and as the principle on which they act is the same in all, nearly everything in their selection will depend on personal tastes and the decoration of the rooms in which they are to be fitted.

Fig. 8 shows a section and Fig. 9 a plan (with cover removed) of the ordinary push, the action of which is briefly as

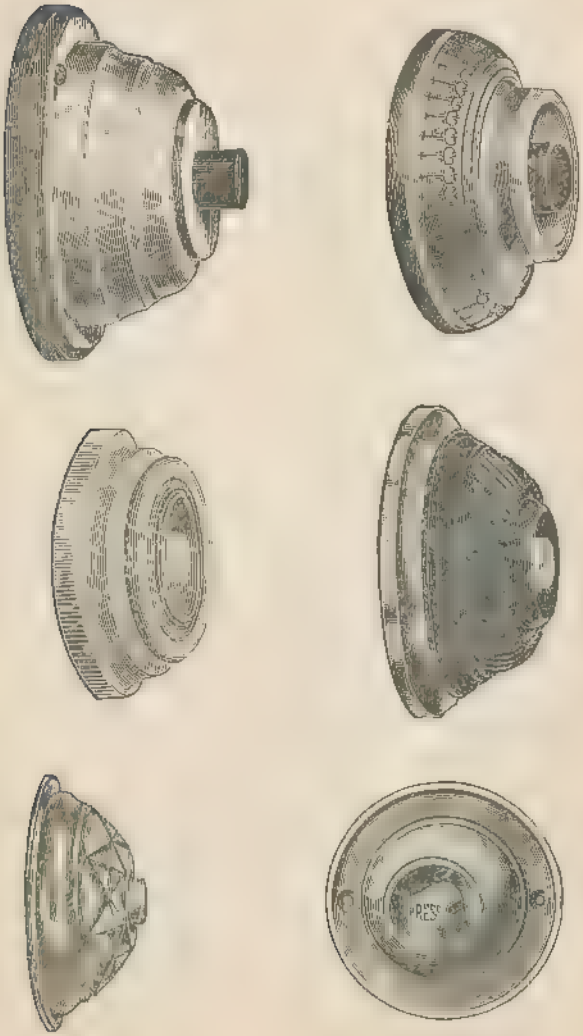
Fig. 8.

Fig. 9.

follows: On the button (*b*) being pushed in, it causes the two platinum tipped German silver or aluminium springs (*s* and *s*), hitherto kept apart by their own tension, to come together and make electrical contact between the two parts of the interrupted circuit, and on the pressure being removed, the button and springs resume their former positions. The cover (*c*) can be easily removed by unscrewing, thus allowing ready access for joining up or inspection.

Fig. 10 shows a variety of wood, china, bronze, and brass

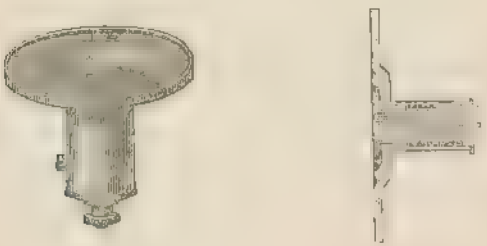
Fig. 10.



pushes. At front and back doors metal pushes (if a pull is objected to) should always be used, as they are better adapted to withstand the exposure to the atmosphere, being generally designed for that purpose. A common defect of the hard wood pushes is the ease with which the screws that hold the ends of the wires are overturned, owing to the screws being too small to bear the turning necessary to get good contact. The buttons of some of the china pushes are also very liable to give trouble, by the rims, that prevent the buttons from coming out, chipping off, when the buttons will no longer remain in the push.

A great improvement over the ordinary pushes is that kind that is known as the "barrel form." A form of this push is shown in Fig. 11. These pushes, which are intended chiefly

Fig. 11.



for front and back entrances, can be very easily fixed, the woodwork being countersunk with an ordinary bit to take the barrel part, and the plate of the push screwed on to the face of the woodwork by ordinary roundhead wood screws. As the button is kept out by a spiral spring, the motion of the button, when pressed, is much more agreeable than in the ordinary push, where the button has a tendency to move on one side in addition to its proper motion.

In fixing the pushes, which should not be done till the building is quite finished, the push (the cover having been previously removed) is screwed to the bevelled wood block

before mentioned, the two wires being brought through the hole in the base and fastened to their respective screws, care being taken to scrape the ends quite clean, and fasten them firmly down to the springs by tightening up the screws.

Fig. 12

In places where the push has to be fastened to laths and plaster, the wall must be probed with a fine instrument to find the laths, and the push firmly screwed on by fine-pointed lath screws.

In bedrooms, pressels, or pear pushes (a form of which is shown in Fig. 12), are often preferred. These are suspended from rosettes fixed against the wall near the ceiling by a two-strand silk-covered wire, in a manner that will be readily understood by reference to the figure. A modified form of these pressels, Fig. 13, but fitted with a weak spring so as to ring by the slightest touch, is much used for invalids, the pressel being laid on the bed and connection made to the rosette by flexible wires, as in the preceding figure. Fig. 14 shows another form of the invalid pressel, to which the name of "feel these peg pressel" has been given, owing to its resemblance to that article. The circuit is closed by squeezing the two prongs together. Fig. 15 shows a contact box, much used for bedrooms, to which the ordinary bell-ropes are attached.

Fig. 13

Fig. 14

The bell is rung by pulling the cord, which causes the arm (*a*) to make contact with the spring *b*, the arm when released being moved back into its former position by the spring (*s*)

Fig. 16 is a combination pear push and contact-box, by means of which the bell can be rung, either by pressing the button or pulling the cord. The two flexible wires from the pear-push

Fig. 15.

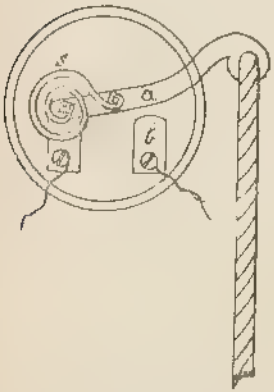
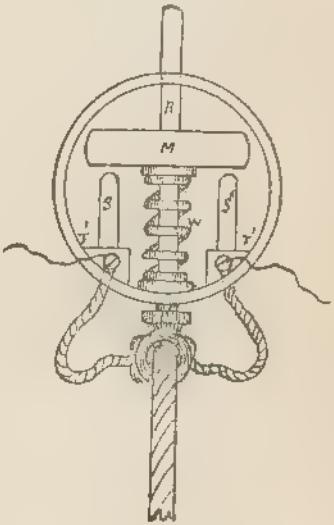
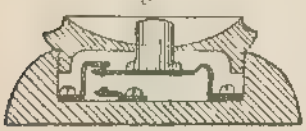


Fig. 16.



(which pear-push is not shown in the figure) are connected to the contacts T and T', so that when the button is pushed the circuit is closed. Again, if the wire is pulled, it causes the rod (R), bringing with it the arm (M), to move down against the pressure of the spiral spring (W), the circuit being completed by the arm (M) connecting the springs (S and S'). On lines where a signal is required to be both sent and received, a form of key, or double contact push, as shown in Fig. 17 (the connections for which will be given subsequently), should be used. In its normal position the spring presses against the top contact, but, on the button being

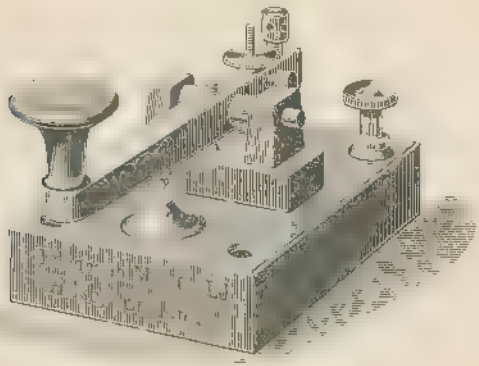
Fig. 17



depressed, moves away from the top contact and is put in connection with the bottom one.

Sometimes a Morse key, Fig. 18, is preferred to the double contact push. The action of the Morse key is similar to that

Fig. 18.



of the double contact push. The horizontal lever, which is pivoted at its centre, is, when at rest, kept in contact with the back stop, but when the ebonite knob is pressed, the lever breaks with the back and makes contact with the front stop.

One of the usual complaints against electric bells is that no means exist of knowing whether the bell has rung after the button has been pressed. To obviate this defect, the Mackenzie sounder indicators were introduced. This ingenious arrangement depends for its action on the well-known Page effect, and will be readily understood by reference to Fig. 19. A is a soft iron core fixed to an iron base D, and surrounded by a bobbin of wire, which is included in the circuit. An iron box C is put over this electro-magnet, having the lid E close to the end of the core. Upon the current flowing round the bobbin, the core A and the lid E, being the respective poles of a continuous magnet, become magnetised with opposite

polarities and emit a sound which continues to be given out so long as the current is passing. As the action is solely molecular, there are no moving parts; thus they are not likely to

Fig 19.

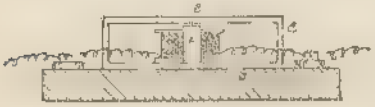


Fig. 20.

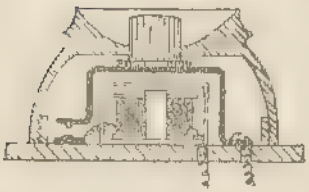
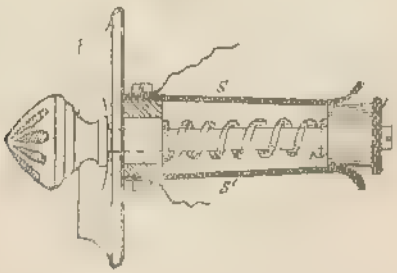


Fig. 21.

get out of order, and should come into general use. Fig. 20 shows an ordinary push fitted with this arrangement, and Fig. 21 a pear-push similarly fitted.

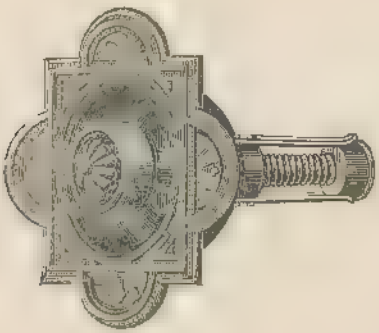
Fig 22



As exposure to dampness is fatal to the ordinary pushes, some form of pull, as shown in Figs. 22 and 23, should be used

for front and back doors, or exposed situations. The two springs S and S' are insulated by vulcanised-fibre blocks from the frame, and, on the knob being pulled out, are electrically connected by the insulated metal disc D, which regains its former position on the knob being released.

Fig 23



In very exposed situations, even the pull is subject to a rapid deterioration. It is then advisable, instead of employing a pull, to fit a contact box similar to Fig 16 in a dry place inside the door. An ordinary crank bell-pull is then fixed outside the door, and connected by a small chain or cord to the contact box inside. When the bell-pull is drawn forward it pulls the cord, which draws down the rod M closing the circuit.

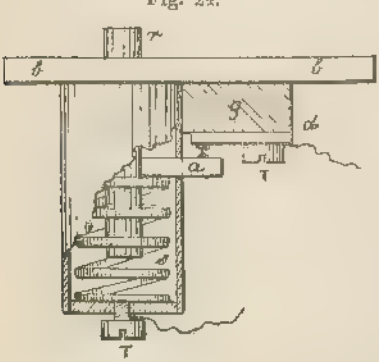
For the back doors of clubs and hotels, all pulls require to be very massive; as the chief delight of the tradesman's boy seems to be trying to see if he cannot wrench the apparatus bodily out of the wall, with the natural consequence that the spiral spring rapidly loses its set, and the disc, not being moved back clear of the springs, the bell rings continuously, to the great detriment of the battery.

Besides the method of closing the circuit by pushes, pulls, &c., there are various other means by which the current is

closed for the purpose of attracting attention or giving an alarm. These are, first, "burglar alarm contacts," under which head come all contacts that are fitted to doors, windows, tills, &c., in such a manner that any movement of the door or window from its normal position will give an alarm by ringing a bell fixed in any convenient place. Second, "fire-alarm contacts," by means of which an alarm is given, either when a prearranged temperature has been reached, or (by using a different form) when any deviation is made from a certain temperature. Besides these, there are miscellaneous alarm contacts, such as for giving warning when the water in a tank has reached a certain level.

The police of an American city recently gave it as their opinion that the great decrease in the number of burglaries that had taken place in that city was due almost entirely to the extensive manner in which the householders had adopted burglar alarms; and there is no doubt that a properly fitted-up system of burglar alarms is the most efficient means of protecting a house. The chief point to be looked to in a burglar alarm is certainty of action in the contacts; and, as the apparatus must stand, perhaps, for months and months together without being called into action, the form of contacts used must be of such a design that they will stand for a long period without any deteriorating surfaces. For this reason a *rubbing action* in the contacts is much to be preferred to a *dotting one*.

Fig. 24.



A form of window contact with a dotting action is shown in Fig. 24. The contact is let bodily into the window-frame till

the brass plate *b* is flush with the surface of the woodwork: then, when the window-sash *e* is shut right down it pushes in the rod *r* against the pressure of the spiral spring *s*, causing the platinum pointed arm *a* to break contact with the brass plate *d*, which is insulated from the framework by the vulcanised fibre block *g*. If the window is now raised slightly the rod is released, and the circuit is closed by the arm *a* moving up to the plate *d*, in which position it is shown in the figure. T T are the two terminals, the one being fixed to the frame and the other to the insulated brass plate *d*.

Fig. 25 shows a form of window contact with a rubbing action. To the bottom of the window-sash *e* is fixed the brass

Fig. 25.

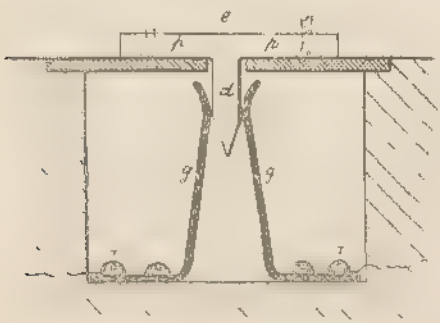
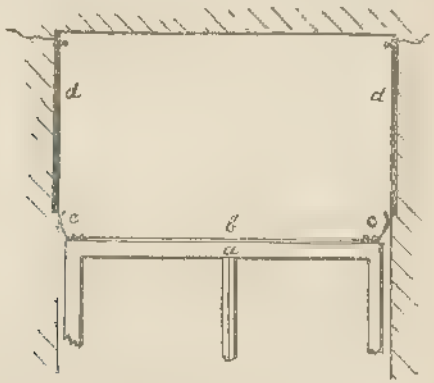


plate *f*, carrying the ebonite wedge *d*. When the window is closed (as in the figure) the two German silver springs *g g* are kept apart by the ebonite wedge; but on the window being opened the wedge is withdrawn, and the two springs come together, thus closing the circuit. It will be seen from this that the rubbing action of the wedge on the springs each time the window is opened or closed ensures their surfaces being kept both clean and bright. Both in this form of contact and in the preceding one another contact (fitted in a similar manner

to the top of the window frame) must be used for protecting the top sash.

A very good arrangement for windows is shown in Fig. 26. A strip of sheet brass, *d*, is let into each side of the window

Fig. 26.



frame, and the two springs *c c*, connected across by the wire *b*, are fixed to the window sash *a*. When the window is shut down in the position shown in the figure, the two springs are off the brass plates *d d*; but any slight movement of the sash upwards brings them at once into contact with the strips, thus closing the circuit. If the strips and springs are nicely let in, the arrangement is not visible at all, while the ordinary opening and shutting of the window insures bright contacts.

For doors, the contact shown in Fig. 21 may be used, being let into the door frame flush with the woodwork on the hinge side of the door. Another form (which is let into the door frame on the handle side of the door) is shown in Fig. 27. The edge of the door (when it is shut) pressing against the ebonite ball *b* pushes it in, causing the platinum-pointed spring *s* (insulated from the brass frame *d* by the vulcanised-fibre block *h*) to move off the contact *c*. On the door being opened the ball is released, and the spring moves up to the

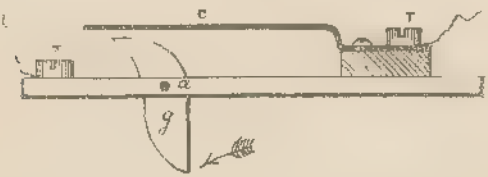
contact c, as shown in the figure. For shop doors, where a momentary contact on opening the door only is desired, the form of door trigger shown in Fig. 28 is generally used. The edge of the door, on its being opened in the direction of the arrow, engages with the trigger *g*, pivoted at *a*, causing the upper end to make contact with the spring c, the trigger slipping by the edge of the door after it has moved a certain distance. It will be seen from this that contact is not made on reclosing the door, as the trigger is moved in the opposite direction.

Fig. 27

For drawers and tills, the form of contacts shown in Figs. 24 or 27 will be found convenient, or a modification of Fig. 26 may be used, the springs c being let into the side of the drawer as shown in Fig. 29.

It is very often desired to be able to summon the servant at meal-times without having to get up from the table and go across the room to the push. For this purpose a contact is usually let into the floor within reach of the carver's foot. Fig. 30 shows the form of contact generally used for this purpose, which is very liable to be injured by an accidental knock, therefore some such

Fig. 28.



form as shown in Fig. 31 is to be preferred. On pressing the brass ball *b* with the foot, the spring *g* is depressed, making

contact with the plate *d*, and returning to its former position when the pressure is removed.

It is sometimes desired to have the push fixed on the table itself, in preference to having a contact in the floor as just

Fig. 29

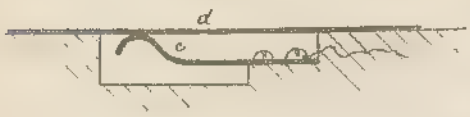
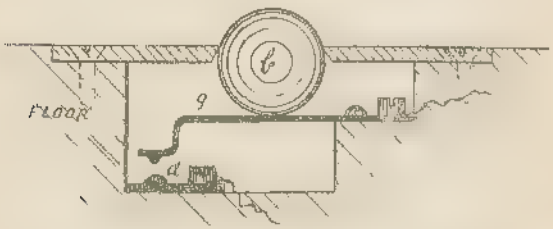


Fig. 30

described. As the table will be moved about it is obvious that no permanent connection can be made between the table and the floor, from whence the wires run to the bell. Therefore

Fig. 31.



the wires from the push must be run down one of the legs of the table, and some such method of connecting the table with the floor as is shown in Figs. 32 and 33 be adopted. In Fig. 32 the wires down the leg terminate in two brass plugs, *a a*. Two brass plates, *b b*, are also let into the floor at the place where the leg generally stands. When it is desired to connect up the push on the table, the plugs, *a a*, are inserted in *b b*, but when

the table is to be moved, or connection is not desired, the plugs are withdrawn, and can be placed in two holes drilled in the

Fig. 32.

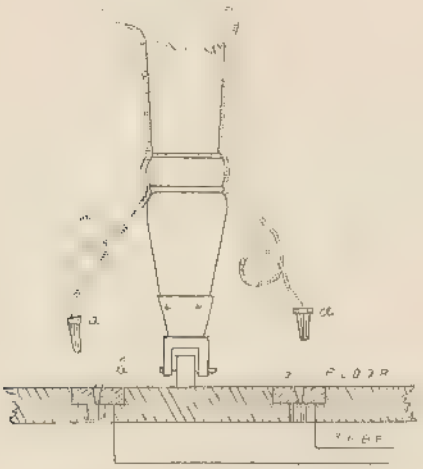


Fig 33.

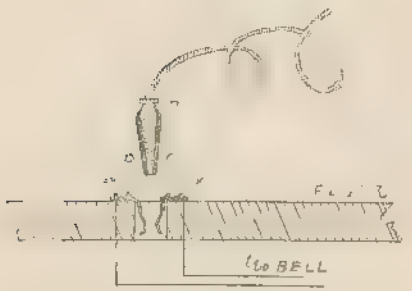
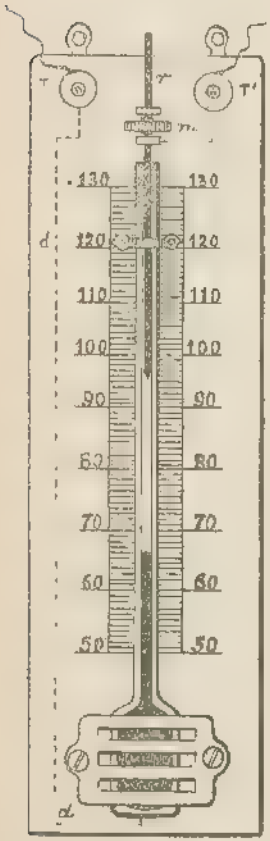


table-leg. In Fig. 33 a twin wire is used down the leg, terminating in the ebonite plate *a*, which has a strip of brass,

c c', fastened each side. A hole is drilled in the floor, and two brass springs, b b', fastened inside. The wires are connected up by placing peg a in the hole in the floor, which causes the plates c' c to make contact with the springs.

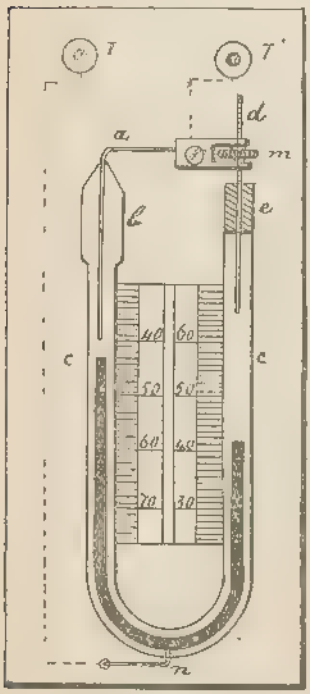
Fig. 34.



A very good form of the fire alarm contact is shown in Fig. 34. It consists of an ordinary mercury thermometer into the bulb of which one end of the wire d has been fused, the other being connected to the terminal T. The other terminal, T', is connected to the platinum rod r, which passes through an india-rubber stopper into the upper end of the tube. Any rise in the temperature beyond a pre-determined point causes the mercury rising in the tube to touch the end of the platinum rod r, thus closing the circuit and ringing the alarm bell. The rod r can, by moving the milled adjusting-screw m, be set for any desired temperature. Differential thermometers fitted in a similar manner are much used in hothouses to give warning to the attendant of any departure, either above or below, from the proper temperature. Fig. 35 shows a form of this thermometer. For the minimum contact a platinum wire a is fused into the bulb b, of the tube c, at the required temperature. Another platinum wire d passes through the indiarubber stopper e into the other end of the tube and forms the maximum contact; it

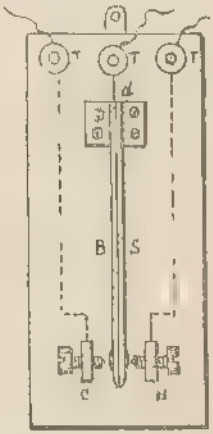
being adjusted for any temperature by the milled screw *m*. A third wire *n* is fused in the glass tube at the bend, this wire being always in contact with the mercury. The bulb *b*, down to the top of the mercury, is filled with spirit. T T′ are the two terminals, the connections being shown by the dotted lines. Any rise of temperature above 65 will close the maximum, while any fall below 40 will close the minimum contact.

Fig. 35.



A simple fire and frost alarm is shown in Fig. 36. A strip of brass, B, is riveted to a strip of steel, S, the tongue thus formed

Fig. 36.



being fixed at one end, *d*, and at the other free to move between the two contact screws C and H. Any rise of temperature moves the free end of the tongue towards H, and any fall towards C. This, form, however, is not so reliable or sensitive as a good thermometer alarm.

Lately quite a variety of fire-alarm contacts have been

devised, some acting by the expansion of air in a closed chamber, and others by the expansion of liquids. None of them, however, have been subjected to a long test, such as is necessary before much confidence can be placed in them. The great drawback to the majority of contacts is their uncertainty of action. They have, perhaps, been standing a long while, during which time dust and moisture has collected on the contacts, and when a fire does break out they fail to perform their duty. A system of unreliable fire alarms is, like a badly designed burglar alarm, worse than if the building had not been fitted at all, as the owner, placing confidence in his alarms, is apt to relax certain precautions, which, were he without, he would not think of overlooking.

Switches are required in electric bell work, either for breaking and making a circuit, or for transferring pushes and contacts from one circuit to another. The two forms of switches most used in ordinary bell work are shown in Figs. 37 and 38, the more complicated switches being but rarely used.

Fig. 37.

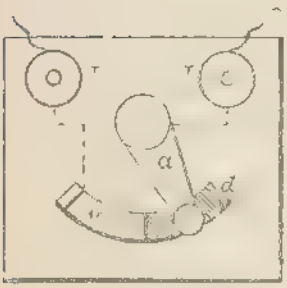


Fig. 38.

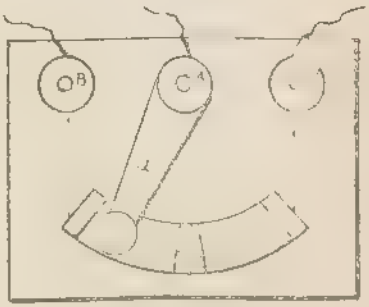
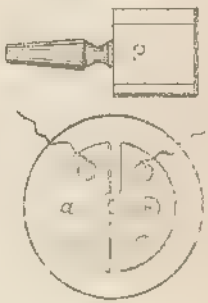


Fig. 37 shows the most simple form of switch. When the arm *a* is moved into the position shown, it is resting against the ebonite block *d*, and the circuit is open, but on moving the arm on to the brass block *b* the terminals T T are connected

through, and the circuit is closed. Fig. 38 shows the three-point switch. When the arm *a* is in the position shown, the terminal A is connected to B; but, on moving the arm on to the opposite block, the terminal A is connected to C. Fig. 39 shows another form of switch for electric bell work.

Fig. 39

Fig. 40



A form of the plug switch or interrupter is shown in Fig. 40. When the plug P is inserted in the hole D, the two brass plates *a a* are connected together and the circuit is closed; but on withdrawing the plug and placing it in the hole H, the circuit is broken. This form of switch, however, owing to the plates widening after a time, is not so satisfactory as the forms previously described.

CHAPTER III.

BELLS, RELAYS, AND INDICATORS.

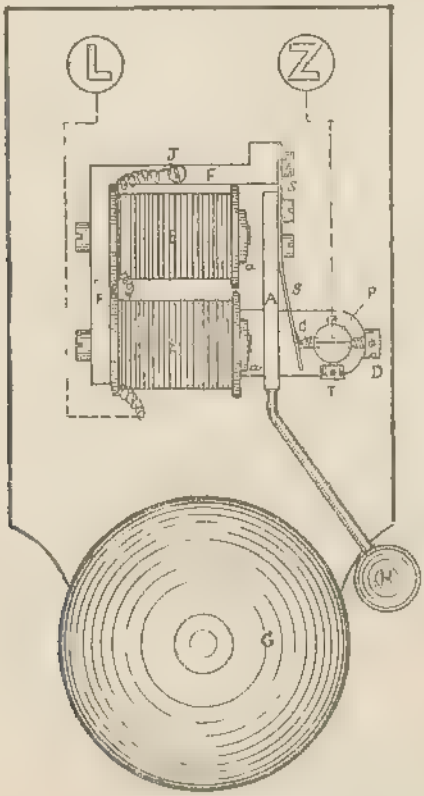
It is of the highest importance in selecting a bell to see that a really substantial and trustworthy article is obtained. All the best bells are now mounted on an iron frame, independently of the wooden base, the coils and contacts being fitted with a removable cover, which, like the base, is usually made in mahogany or teak. Uncovered bells should never be used, on account of dust getting into the contacts, and bells fitted with boxwood or vulcanized-fibre bobbins are much to be preferred to those with metal ones. All contacts should be made of platinum; and if platinum is paid for, care should be taken to see that it is really obtained, as a white metal, such as German silver, is frequently palmed off on the unwary.

The form of bell most frequently used is the trembling or vibrating bell (Fig. 41), which consists of an electro-magnet E firmly fixed to the iron frame F, and provided with a soft iron vibrating armature A, one end of which is fitted with a hammer H, and the other fixed to the iron frame by a spring S, the lower end of which carries a platinum contact C. Fixed to the iron frame, but insulated therefrom, is a contact post P, fitted with an adjustable platinum-pointed screw D, and a tightening screw T, which, when screwed up, entirely prevents the adjustable screw D working loose, as it has a great tendency to do.

The action of the bell is as follows: The current, entering at the terminal L, flows round the coils of the electro-magnet E, and thence by screw J to the frame, by armature and

spring S to contact C, platinum-pointed screw D, contact post P, and thence to terminal Z. But in thus flowing round the coils of the electro-magnet, the current has magnetised the

Fig. 41.



cores, which now attract the armature A, causing it to move up to the poles *a a*, bringing with it the hammer H, which is impelled against the gong G, and at the same time the contact C moves away from the screw D, thus breaking the circuit. As

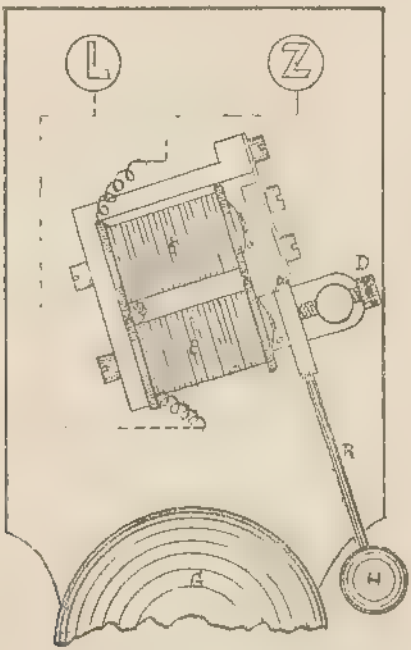
the cores of the electro-magnet E are made of soft iron, all magnetism now practically ceases, and the armature A, in obedience to the spring S, moves back into its former position only to repeat the previous operation so long as the button of the push is kept in.

To adjust a trembling bell it will be necessary to make sure that all the connections are tight; then holding the hammer H against the gong G, slacken screw T, and screw up the adjustable screw D till the platinum point is just clear of the contact C. Then let go the hammer and see if the spring draws the armature back so as to cause C to make good contact with D; then tighten up screw T. See also that the armature, when attracted, does not touch the poles *a a*, or there will be a tapping sound while the bell is ringing. If the screw D is screwed up too far the spring will not break contact with it, while if it is not screwed up far enough the sound will be feeble, since the hammer will not reach the gong with such force. Sometimes a bell rings badly from the spring either setting the armature back too strongly, or from being so weak that it does not bring it back with sufficient rapidity. To find out which is the true cause, take a piece of wire, or better still, a piece of watch-spring, and whilst the bell is ringing press the armature towards the poles; then if the ringing is improved the spring is too strong, and must be taken off and set a little inwards. If, on the contrary, the ringing improves when the armature is pressed away from the poles, the spring is too weak, and must be set a little outwards.

In many cases communication is desired between two places by means of certain prearranged signals, such as a certified number of strokes of the bell. For this purpose the single-stroke bell, a form which is shown in Fig. 42, must be used. This is the electric bell in its simplest form, consisting of an electro-magnet E, an armature A, and a stop-screw D, to prevent it being moved too far back from the poles. When the push is pressed, the electro-magnet draws up the armature, striking the

hammer against the gong, and retaining it there so long as the circuit is closed; but on the circuit being broken, the armature moves back into its normal position, which is, resting against the stop-screw D. A stroke of the bell is thus obtained each time the button is pressed.

Fig. 42.

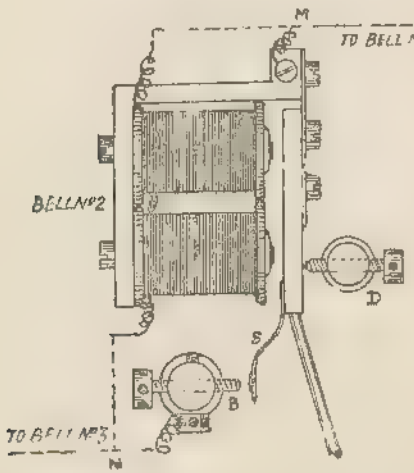


To adjust a single-stroke bell so that a clear sound is obtained, push the armature A up to the brass studs (shown black in the figure) which are driven in the ends of the poles *a a*, then bend the rod R so that the hammer H is just clear of the gong G. Now let go the hammer, and adjust the screw D till the best effect is obtained. If the hammer touches the gong before the

armature reaches the stops a harsh sound will be produced, owing to the hammer stopping the vibration of the gong.

It is very often desired to place two or more bells in series on one circuit. If the bells are single-stroke no difficulty presents itself, but on attempting to do this with the ordinary trembling bell, the ringing becomes at the best very indifferent and spasmodic, arising from the fact that as the bells are not exactly similar, they do not make and break the circuit in unison. One way of getting over this difficulty is to have one of the bells a trembling bell and the rest single-stroke, the trembling bell governing the vibrations of the single stroke; but even when arranged thus, unless the bells are very much alike, the ringing is rarely satisfactory. Perhaps the best plan is to use the form of bell shown in Fig. 43, which, as will be seen from the figure,

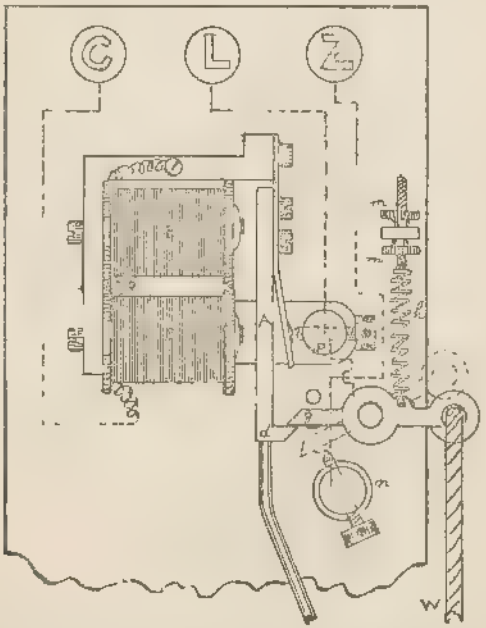
Fig 43



governs its vibrations, not by breaking the circuit, but by shunting its coils. On the current flowing round the electro-magnet E, the armature is attracted, and the spring S makes contact with

the screw B. There now exists a path from M to N of practically no resistance; the current, therefore, is diverted from the magnet coils, and passes by the armature and screw B to the next bell, the armature falling back against the stop-screw D, and repeating the previous operation so long as the circuit is closed. Thus, no matter how many bells there may be in the series, the circuit is never broken. This form of bell, however,

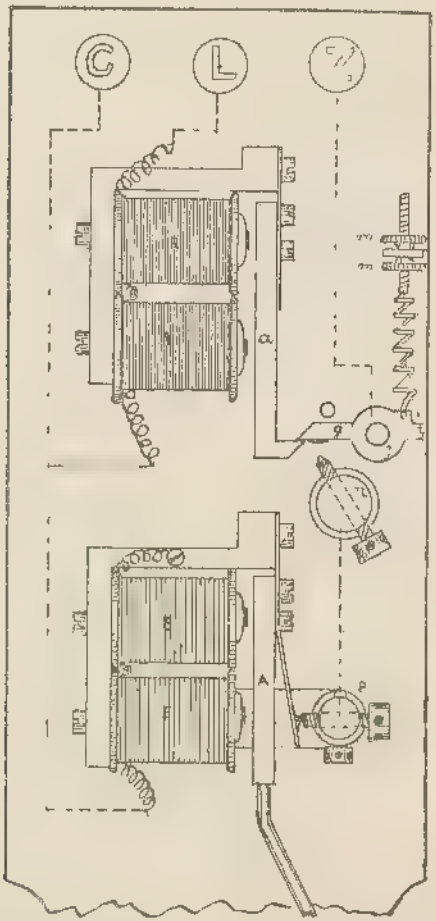
Fig. 44



does not ring so energetically as the ordinary form, with a corresponding amount of battery power. No difficulty will be experienced in arranging two or more bells (either trembling or single-stroke) in parallel on the same circuit, so long as care is taken to provide sufficient battery power.

Very often, as in connection with a system of burglar alarms, &c., a bell, when once started, is required to ring continuously.

Fig. 45.

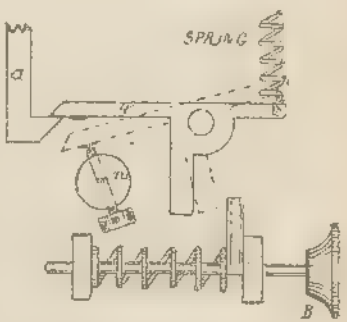


For this purpose what is known as a "continuous ringing" bell must be employed. The most general form of this bell is shown

in Fig. 44, the construction of which is similar to the trembling bell just described, but with this addition: The lower end of the armature A is fitted with a catch *d*, which engages with a lever *g*, to which is fixed a spiral spring *h*, the tension of which is regulated by the milled screws *m m*; an extra contact post and screw *n*, fixed beneath the lever *g*, is also provided. The action of the bell is as follows:—The current flows at first from terminal C to L, as in the trembling bell; but on the first stroke of the armature A, the lever *g* slips off the catch *d*, and falls against the contact screw *n* in the position shown by the dotted lines. The current now flows from terminal C round electro-magnet L' to frame, armature A, and upper contact post P', thence to lever *g* and lower contact post *n*, and then to terminal Z, the bell continuing to ring until the cord W is pulled, which breaks the circuit by resetting the lever.

Another form of continuous ringing bell, which is to be preferred from its being more certain in its action, is shown in Fig. 45. In this bell the lever is released, not by the bell armature, but by the armature of a relay fixed above the bell coils. On the push being pressed, the current entering a terminal C, passes through the relay coils R and out at L. The relay armature being attracted, releases lever *g*, which makes contact with *n*. The current now flows from terminal C, through the bell coils, to the frame and armature A, lower contact post P, thence to upper contact post *n*, lever *g*, and out by terminal Z; the bell continuing to ring until the lever is reset as before. Fig. 46 shows a form of press replacement to be preferred to the cord when the bell is within reach, in which the lever *g* is replaced by pressing the button B.

Fig 46.



A form of continuous ringing bell, which, among its other advantages, can be reset from a distance, has lately been introduced. This will be described subsequently, when the diagrams for connecting up the bells, &c., are given, as its action will then be more readily understood.

Fig. 47.

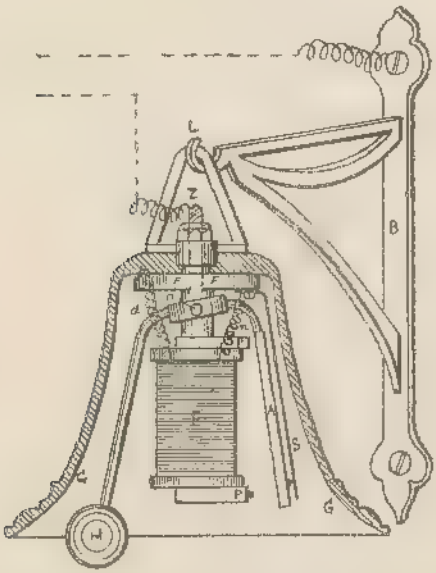
Fig. 47 shows a bell complete with cover on.

Having described the different kinds of electric bell movements, we may now proceed to investigate some of the various

forms which these movements take. When a bell is so designed that the movement is all contained in the gong, it is known as a "circular bell," and when the gong takes the shape of a church bell it is known as the "church bell" pattern.

Of the variety of bells having the movement contained within the gong, the Jensen church-shape bell, owing to its neat appearance, the simplicity of its movement, and the purity of its tone which, it would seem, is only to be obtained by this shape gong is without doubt entitled to the foremost place.

Fig. 48.



Its general construction can be seen from Fig. 48. Inside the gong is placed a single magnet of special construction, the armature of which, besides being magnetised by induction, is directly polarised by being in actual magnetic contact with the iron core of the magnet; it is thus induced to perform a large

amount of work with comparatively small power. P P are the poles of the electro-magnet E, to an extension of the core of which is fixed the armature A, pivoted at O, and in its normal position resting against the contact spring S. The bell is supported at L by the bracket B, which in practice becomes one terminal, the other being formed by the nut and screw Z, which carries the movement; the whole being insulated from the gong G by the insulating material I. The bell in the figure is shown connected up as a trembling bell. If a single-stroke bell is desired, the wire, instead of being fastened to the spring S, is directly attached to the movement. On the button being pressed, the current flows by bracket B and lug L to the gong G; thence by wire *d* to magnet coils E, wire *a*, spring S, armature A, pivot O, leaving by terminal Z. In many instances

Fig. 49.

(see Fig. 49) the wire, instead of being taken directly to terminal Z, is fastened to a spring, one end of which is fixed to (but insulated from) the bracket B, and the other presses firmly on the top of the screw Z. Thus the bell can be readily taken off the bracket and replaced without disturbing any connections.

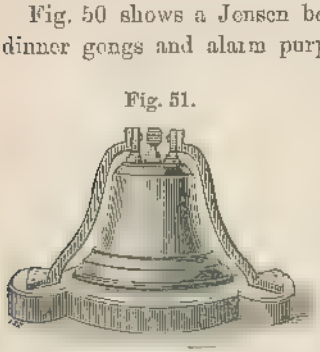
The bell shown in Fig. 48 is the most simple form of the

Fig. 50.

Jensen bell, there being a pole-piece fitted to one of the poles of the electro-magnet only, the other being extended out through the core and gimbal to the armature, which thus exhibits opposite polarity to the pole at the bottom of the electro-magnet. The more expensive forms have two pole-pieces, one at each end of the bobbin, the armature being magnetically insulated from the electro-magnet by the extension of the core beyond the top pole-piece being made of brass. In the large size bells the armature is wound in addition to the magnet, the coil on the armature being in a reverse direction to that on the magnet, the two coils being afterwards joined in series. In the more expensive vibrating bells, an arm, fixed to the boxwood base, and having at the lower end an adjusting screw, is employed, thus giving greater facilities for adjustment; though in the larger bells, where a vibrating action is desired, the inventor prefers to join up the bell as a single stroke, and insert a separate make and break in the circuit, which can be placed in any easily accessible and dry place.

Fig. 50 shows a Jensen bell, such as is generally used for dinner gongs and alarm purposes, combined with an electric light fitting for fixing in the hall. Fig. 51 shows a form of the Jensen bell designed for use on board ship.

Fig. 51.



Messrs. Jensen have also given great attention to adapting their large bells for factories and use at Board Schools, in place of the usual method of ringing the bells by a rope. Several very large bells have been fitted up for these purposes, and the ringing has been all that can be desired. A separate clockwork make and break is used in conjunction with these large bells, by moving the adjustment of which the rapidity of the strokes can be varied to a nicety. Fig. 52 shows a big bell

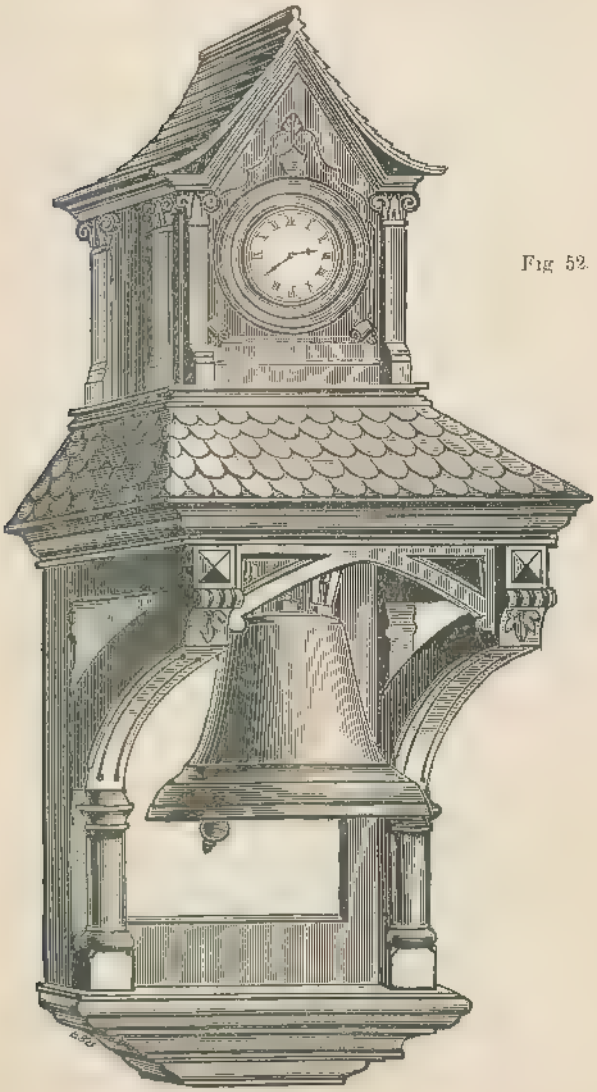


Fig. 52.

fixed on a bracket in conjunction with a clock, the clock causing the bell to strike the hours or ring continuously at intervals, such as is necessary in factories to give notice to the men for the cessation of work.

Fig. 53 shows a circular electric bell, mounted on a wooden base, as manufactured by Messrs. Binswanger. Where a number of bells are used in preference to one bell and an indicator,

Fig. 53

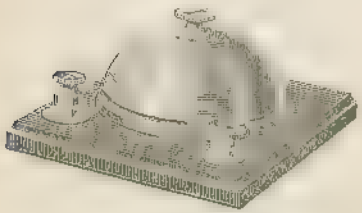
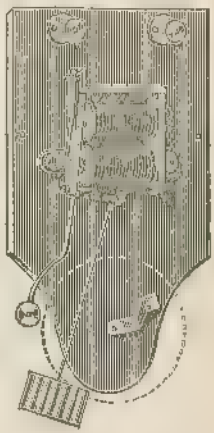


Fig. 54



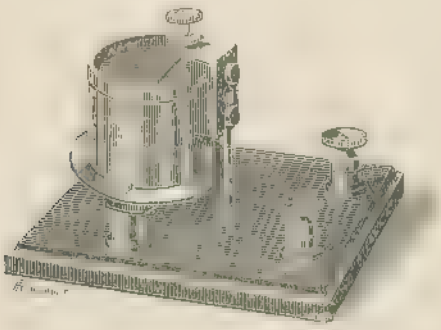
unless the servant happens to be close at hand when the summons is given, it is very difficult to tell which bell has rung. Fig. 54 shows a useful arrangement devised by Messrs. Binswanger, which can be attached to an ordinary electric bell, and completely does away with this objection. As will be seen from the figure, a light vane is fixed at one end of a rod, the other end of the rod being pivoted at a point just below the bottom bobbin. A projecting arm is fixed at the bottom of the armature, and, when the bell is rung, this arm engages with the rod, causing the vane to swing; the vane continuing to swing for some time after the bell has ceased to ring. This form of bell, however, requires more battery power than the ordinary form.

In mines, large single-stroke bells are much used for the purpose of signalling between two places, the movement being enclosed in a substantial wooden case, and the gong fixed on

the top. A Morse key is generally used in conjunction with these bells, the keys very often being fixed on the same base as the bell.

Where a loud noise is not desired, such as when the head of a firm wishes to call a clerk from an adjoining office without disturbing the rest, a piece of apparatus called a "buzzer" is frequently employed. This instrument, which is fixed close to the desk of the clerk to whom it is required to signal, consists of an electro-magnet, fitted with an armature and contact screw, being in fact an electric bell movement minus the hammer. When the circuit is closed the armature vibrating to and fro makes a buzzing sound, which, though perfectly audible, has not the penetrating effect of the electric bell.

Fig. 55.



An improvement on the buzzer has lately been introduced by Messrs. Binswanger, to which the name of "electric trumpet" has been given. Fig. 55 shows the electric trumpet consisting of an ordinary electro-magnet, opposite the poles of which is fixed a thin sheet iron disc. In front of the disc is a platinum pointed contact screw, the point of which presses against a piece of sheet platinum fixed on the iron disc. One of the poles of the battery is connected directly to the frame of the trumpet,

and the other, after passing through the push, to the insulated platinum pointed screw. When the disc is attracted the circuit is broken through the contact screw. It will be seen from this that when the push is pressed, the current flows round the coils of the electro-magnet, causing the armature or iron disc to vibrate very rapidly, giving out a loud musical sound.

Besides the methods previously described of making bells continuous ringing, there are several others that may be adopted. The indicator drops may be so constructed that they keep the circuit closed after the vane has fallen, or, what is preferable, where the bell is of large size or there are many bells to be rung at the same time, some arrangement, quite apart from the bell and indicator, the sole object of which is to keep the circuit of the bells closed after the push has been pressed or contact

Fig. 56.

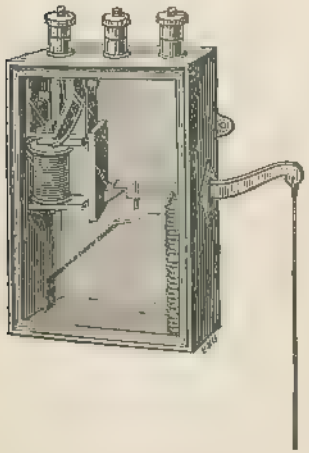
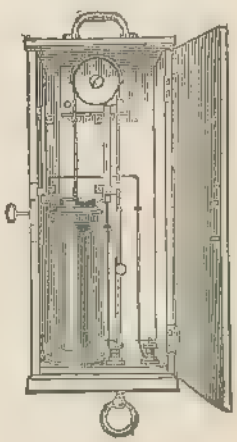


Fig. 57.



moved. These are known as "continuous ringing attachments," a form of which is shown at Fig. 56.

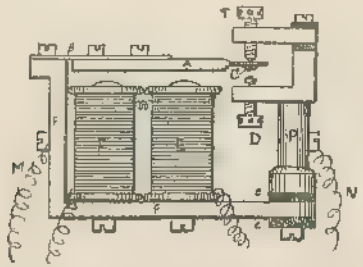
A very ingenious arrangement for closing and keeping closed, the circuit of one or more bells for a certain time, has been

devised by Mr. H. Thorpe. The arrangement is shown in Fig. 57. When the ring at the bottom of the case is pulled downwards, the plunger is drawn out of the tube, two springs on either side making contact with two rods fixed one on each side. This closes the circuit, causing the bell or bells to ring. The ring being released, the plunger slowly sinks into the tube, the bells continuing to ring until the plunger has sunk to the bottom, when the springs break contact with the rods, and open the circuit. By altering the position of the pin in the rod seen in the centre of the case, the length of time that the bells ring can be varied from 5 to 30 seconds.

Relays will be necessary on long circuits, where, from the resistance of the line, the current has not strength enough to ring the bell, but quite sufficient to attract the delicately poised armature of a relay. Many forms of indicators are also greatly improved by the addition of a relay, and when greater certainty of action is desired in an indicator a relay should always be fixed, to insure its effective working. The duty of a relay is to close a local circuit when actuated by a current circulating through its coils.

A form of the single-current relay is shown in Fig. 58.

Fig. 58.

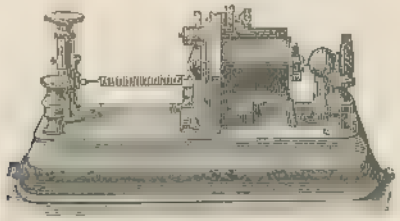


When a current circulates in the coils of the electro magnet E E, the armature A is attracted, and the platinum contact C is pressed against the screw D. This closes the local circuit;

the current flowing from wire M to frame F, armature A, contact C, screw E, to post P (insulated from the frame by the ebonite washers *e e*), leaving by wire N. The arm carrying the stop-screw T is also insulated from the post P by ebonite washers. In adjusting a relay, first screw up the screw D, so that when the contact C is pressing firmly against the point there is just room to pass a piece of paper between the poles and armature. Then adjust the stop-screw T, so that the contact C only fairly leaves the screw D. The tension of the spring S should only be such as will just bring the armature back against the stop-screw T.

Fig. 59 shows a form of relay as used for telegraphic purposes.

Fig. 59



Where there are many rooms, and all are desired to ring on the same bell, an indicator must be used, so that the ringing from one room can be distinguished from that of another. In many instances, however, where there are only three or four rooms, it is preferable to employ a different toned bell for each room; thus the servant can attend immediately to the summons without having to go first to look at an indicator. The indicator in its pure and simple form was introduced into this country from the Continent, where the use to which electric bells are put is very extensive, it being quite the exception to find the old style of bell. At the hands of the manufacturers in this country it has received great improvement, and the variety of

forms has become almost numberless. They may, however, be divided into two distinct classes, viz. those that drop a shutter or move a disc, and require to be reset each time the bell is rung, and those that require no resetting, depending for their action on a pendulum which, when once started, swings for a considerable time. This latter form are called automatic or self-replacing indicators.

The first class is capable of being again divided into two classes: (1st) those in which the replacement or throwing back of the vane is effected by mechanical means; and (2nd) those in which, by pressing a button, a current of electricity from the battery is made to effect the replacement. The former are known as mechanical, and the latter as electrical "throwbacks." Of the two, for general purposes, the latter class is much to be preferred, as an extensive use of the former has proved that servants cannot be implicitly relied on to replace the shutter. Thus when the bell rings there are perhaps some half-dozen shutters down, and great annoyance is caused by the servant not directly answering the summons. For this reason, and because from their simplicity they are more certain in their action, the pendulum indicators are rapidly coming into favour.

Fig. 60.

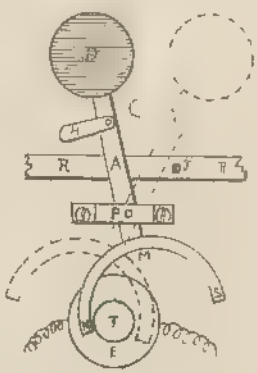


Fig. 60 shows a form of the electrical throwback indicator, consisting of an upright arm A, pivoted at P, one end of which carries the disc D, and to the other is fixed the permanent magnet M, with its north and south poles N S projecting downwards. An electro-magnet E, wound with two coils, is fixed to the framework in such a manner that the pole T comes between the poles of the permanent magnet N. On a current flowing round the electro-magnet, the core becomes magnetised, the

pole T exhibiting, let us say, north polarity. Then, since like magnetic poles repel, and unlike attract, the pole T repels the pole N, and attracts the pole S of the permanent magnet, throwing it over into the position shown by the dotted lines. The disc is moved back into its normal position either by pressing a push, so connected that it sends a current in the reverse direction round the electro-magnet, or by the rod R being moved by mechanical means, so as to cause the stud J to push over the arm A. The little arm H which is fastened to A, can be moved into any position, so as to allow of the balance being restored should the indicator get out of adjustment.

A form of the mechanical throwback indicator is shown in Figs. 61 and 62, which consists of an electro-magnet E, provided with an armature A, pivoted at Y, and to which is fixed a light

Fig 61.

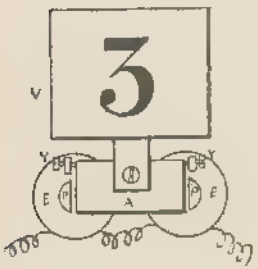
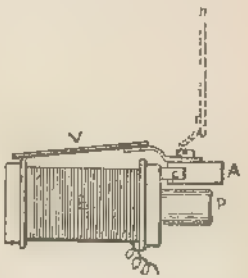


Fig. 62



cardboard vane V. When a current flows round the electro-magnet, the armature is attracted by the poles P P, and the vane is moved up into the position shown in Fig. 61, and by the dotted lines in Fig. 62. The indicator is reset by pulling a cord, which causes a light metal rod to throw back the vane into its former position.

Fig. 63 shows a form of the pendulum indicator, consisting of an electro-magnet E, provided with an armature A, one end of which is fastened to a spring S, supported by the post P, and

the other carries a vane of corrugated silver glass, which, besides being visible in dark situations where a coloured vane would be useless, has the advantage that the slightest movement can be readily detected even from a distance. On a current flowing round the electro-magnet, the armature is attracted and held against the

Fig. 63.

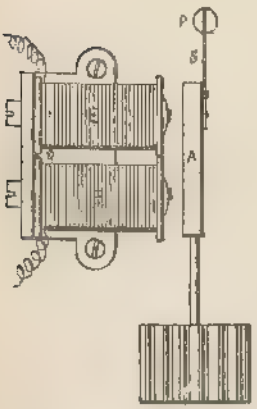
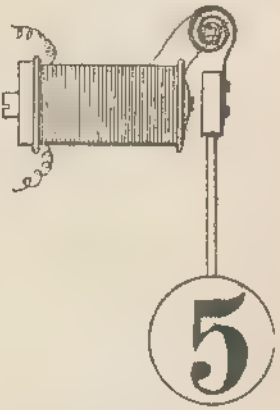


Fig. 64.



poles so long as the circuit is closed; but on the circuit being broken, the armature is released, and swings backwards and forwards for about two minutes, finally returning to its normal position, as shown in the figure. Another form of the pendulum indicator is shown in Fig. 64, which works on the same principle as the preceding one. This form of indicator is not contained in a case like those previously described, but is generally fixed to an ordinary board placed in some conspicuous place. A relay should always be used in conjunction with the pendulum indicators, as the continual make and break of the circuit by the bell greatly interferes with their satisfactory working.

Fig. 65 shows a case, with cover removed, of six pendulum indicators of the form described in Fig. 63, the connection to the terminals being shown by the dotted lines. As will be seen

from the figure, a relay R, which closes the bell circuit when its armature is attracted, is fixed in the right-hand side of the case.

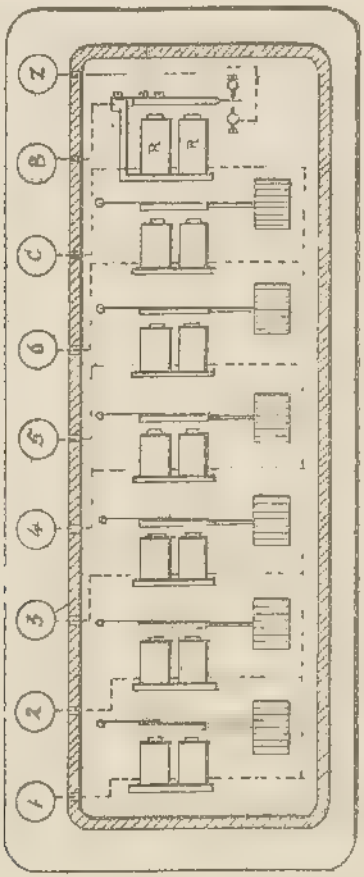


Fig. 65.

A compact form of the mechanical throwback indicator designed by Messrs. Jensen is shown in Fig. 66. It will be seen that, as in their bell, a single coil magnet of special construction

Fig 66

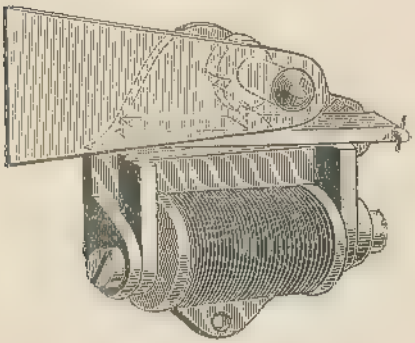
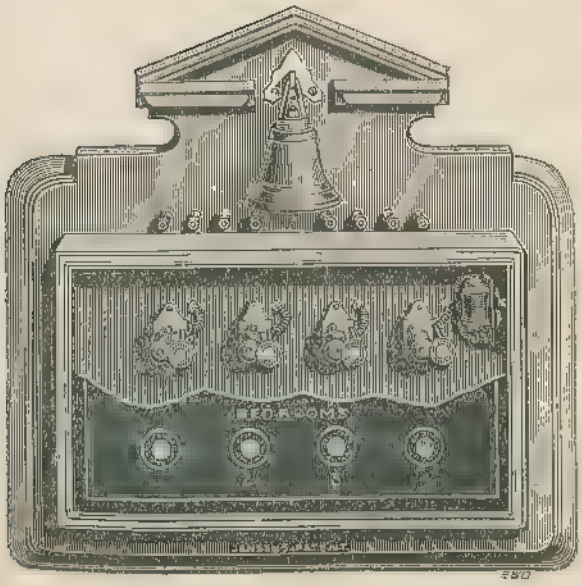


Fig 67.



is used, in which the armature, when attracted, releases the horizontal arm, the arm swinging round till the detent on the armature engages with the second notch on the vane, as shown by the dotted lines. Fig. 67 shows a Jensen indicator with a bell on a bracket at the top, the case containing eight movements of the pendulum type and a relay. The front part of the indicator face is broken away, showing the four top movements.

Fig. 68

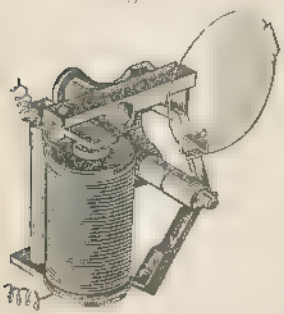
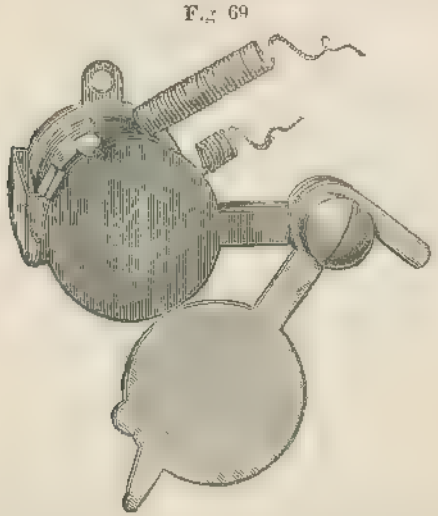


Fig. 68 shows an indicator movement manufactured by Messrs. Binswanger. In this movement two iron cores are provided, one of which only is wound. Above the magnet is pivoted a horizontal arm, one end of which carries the armature, and on the

Fig. 69



other end are cut the two teeth that retain the vane in position. When the armature is attracted these teeth release the vane,

which being pivoted, as shown in the figure, falls over, indicating the number of the room from which the signal has been sent.

A form of mechanical throwback indicator movement, devised by Mr. Thorpe, is shown in Fig. 69. This movement, which is known as Thorpe's "semaphore indicator," consists of an electro-magnet, in front of which is fixed an armature of thin sheet iron. In front of the armature is a thin brass disc, pivoted by means of the screw seen at the right of the figure, this screw also holding the armature in position. The number of the room is painted on the face of the armature. When a current circulates in the coils of the electro-magnet, the armature is attracted, releasing the front disc, which falls down into the position shown in the figure, thus disclosing the number.

CHAPTER IV.

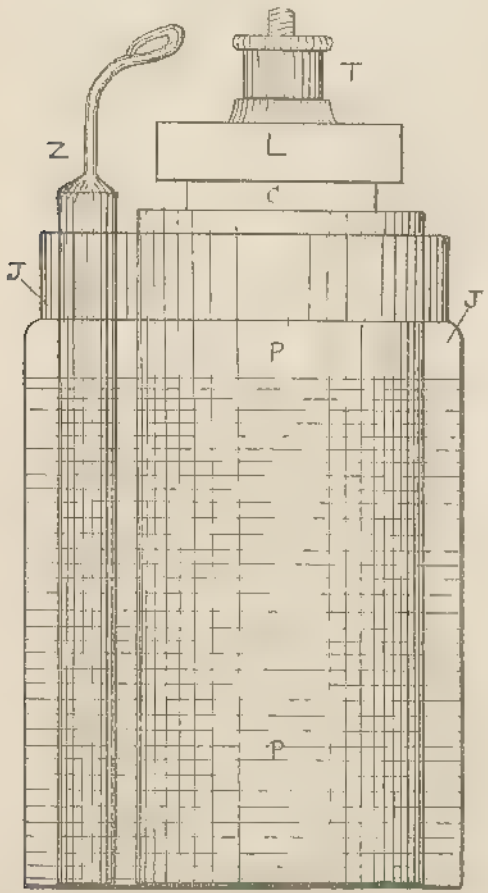
BATTERIES.

THERE are four different forms of batteries that may be employed for electric-bell work—1st the Leclanché, 2nd the Fuller bichromate, 3rd the Gassner, and 4th the Daniell; this last form being only used for "closed circuit" work. The Gassner dry battery, however, has only lately been introduced, and therefore cannot as yet be said to have been subjected to any lengthy trial.

A severe and prolonged test extending over many years has proved that for general electric-bell work the Leclanché battery has no equal, though in large hotels, &c., where the work is likely to be very heavy, it may, perhaps, be preferable to employ a form of the Fuller bichromate battery. It is very important that the battery employed should be a thoroughly reliable one, and set up in a proper manner, as a failure of the battery causes a breakdown in the communication throughout the entire building, whilst the failure of a push or wire only affects that portion of the building in which the push or wire is fixed. A common fault is that of putting in (with a view to economy) only just enough cells as (when first set up) will do the necessary work. This is false economy, as when the cells are but slightly exhausted the battery-power becomes insufficient; whereas, if another cell or two had been added the battery would have run a much longer time without renewal, owing to the fact that each cell could have been reduced to a lower state of exhaustion, yet still the battery would have furnished the necessary power; and the author has always

found that the extra expense of the surplus cells is fully repaid by the increased length of time the battery runs without renewal.

Fig. 70.



The Leclanché cell, Fig. 70, consists, in its most usual form, of a glass jar, J, in which is contained the amalgamated zinc

rod Z, forming the positive element. The negative element (which is also shown in section in Fig. 71) consists of a carbon

Fig. 71.

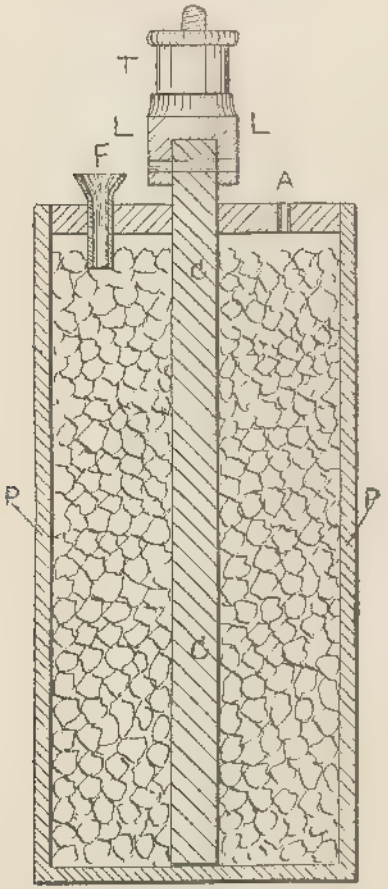
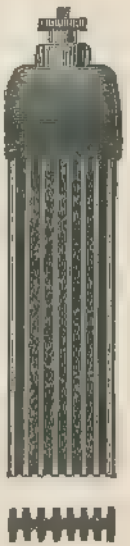


plate C, placed inside the porous pot P, and surrounded with a tightly-packed mixture of carbon and peroxide of manganese, the top of the porous pot being run in with melted pitch. In

some forms of cells the corrugated carbon plate of the form shown in Fig. 72 is used. The Leclanché is a single fluid cell, the porous pot serving not to keep two fluids separate, but merely to contain the broken carbon and manganese, and keep it in intimate contact with the carbon plate. The exciting fluid is a solution of salammoniac.

Fig. 72.

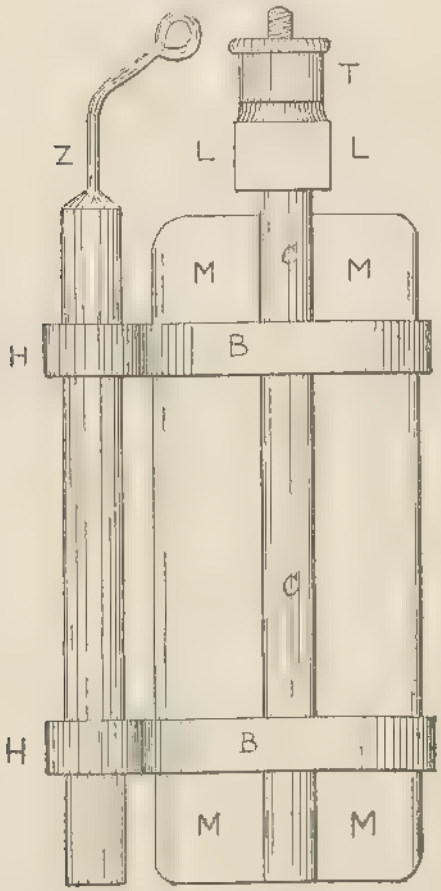


This solution has no chemical effect either on the zinc (provided it is pure) or the peroxide of manganese, so long as the circuit is broken and the cell not at work. But on the circuit being closed a current flows from the positive pole C, to the negative pole Z, and the action in the cell is as follows. The solution of chloride of ammonia (salammoniac) is decomposed; the chlorine, attacking the zinc, forms chloride of zinc, which is soluble in the surrounding liquid; while the ammonia, developing at the surface of the carbon, forms a soluble compound with the oxygen which it extracts from the manganese. While the cell is at work, then, the zinc is consumed, and chloride of zinc accumulates in the solution, the carbon remaining unaltered, and the peroxide of manganese loses some of its oxygen. After a time, however, the supply of oxygen gets reduced, and hydrogen accumulates on the surface of the carbon plate, producing polarisation. But if the circuit is now broken, and the cell left to rest for a time, it will depolarise; the peroxide of manganese absorbing oxygen from the air.

The terminal T is fixed to the carbon plate (in a manner that will be readily understood by referring to Fig. 71) by means of the lead cap L. Simple as this battery seems, it is one of the most difficult to manufacture, and great care is necessary in fixing the lead cap, as if improperly done, the salts creeping up will rapidly eat away the connection.

Before the lead cap is fastened on to the carbon plate, the top end of the plate is soaked for an hour or so in melted paraffin

Fig 73



wax at a temperature of 110° C. to prevent the creeping of the salts. Two $\frac{1}{4}$ inch holes are then drilled through the carbon

plate and the cap cast on, the lead which runs into these holes serving as rivets.

Another form of the Leclanché cell, known as the "agglomerate block" form, is shown in Fig. 73. In this form of cell a porous pot is not used, the depolarising mixture being applied to both sides of the carbon plate in the form of a block. The materials used in the construction of these blocks, which are similar to those contained in the porous pot, with the addition of from 5 to 10 per cent. of some cementing compound such as resin, are during manufacture submitted to a pressure of many tons.

In fitting up a cell of this form an agglomerate plate M is placed each side of the carbon plate C, and the two indiarubber bands B B slipped over them. These bands have at H a solid part, through which a hole has been stamped to receive the zinc rod. The zinc is thus kept from touching the negative element, and both elements can (by lifting at the positive terminal T) be taken bodily out of the glass jar.

When these cells were first brought out great things were expected of them, and the following were the chief advantages claimed for them over the porous pot form:—

That a much better use was made of the depolarising power of the manganese, as its reduction was more complete; that, in consequence of the readier reduction of the manganese, the carbon plate was more rapidly depolarised, and consequently the E.M.F. was more sustained.

That its resistance was extremely constant whatever the electro-chemical work done by the cell, and would, if anything, tend to diminish owing to the formation of chloride of zinc, which is an excellent conductor.

That the battery was ready for use immediately on charging, as the liquid was brought at once into contact with the negative and positive elements.

That the renewal was exceedingly simple when a cell is exhausted the depolarising plates have only to be removed and fresh ones substituted.

A short trial of them, however, for practical work proved that they were no improvement over the preceding form. Their chief virtue is, of course, their low internal resistance (owing to the non-use of the porous pot), though this is a doubtful advantage, except, perhaps, for bells arranged parallel. An injurious local action is also set up by impurities detached from the blocks settling on the rubber bands, and the consumption of zinc seems to go on just as much when the cell is at rest as when it is at work. This cell also polarises quicker than the porous pot form, while it is exceedingly dirty to handle, and in the author's opinion nothing beats the old porous-pot form as shown in Fig. 70.

A creeping of the salts up the inside and over the outside of the glass jar, is a fault to which the Leclanché cell is very liable. This can, however, be entirely prevented by rubbing the neck of the jar with a little grease, or by dipping it for an inch or so in melted paraffin wax.

A good way to paraffin the top of the glass cells, is to melt the wax in some vessel, the mouth of which is wide enough to admit of a cell being inserted. A piece of glass tube, bent to the form of the letter U, is placed inside the vessel that contains the wax, both ends of the tube being above the surface of the wax. The glass cells having been previously warmed, are then dipped (mouth downwards) into the melted wax, one end of the glass tube passing inside the cell and the other remaining outside exposed to the air. This allows the wax inside the cell to rise at once to the level of that outside, instead of (if there was no tube) being prevented from entering by the pressure of the air.

With a view also to prevent this creeping, the cells are sometimes sealed, i. e. the top is filled in with pitch, a hole being left for charging. The use of sealed cells, however, is not economical, as when exhausted they cannot well be recharged.

The position of the battery is a matter of some importance, as in warm or moist situations the creeping of the salts is

greatly hastened. It should be placed on a shelf or in a cupboard near the bell. If this is not possible, the coolest place should be selected, keeping in mind, however, that it should be near its work.

The Leclanché cell is made in three sizes Nos. 1, 2, 3—No. 1 being generally the smallest. Some manufacturers, however, number their cells in exactly the opposite manner, then No. 1 being the largest. It is a pity that some standard method of numbering is not adopted, as it often leads to great confusion when ordering, though there is perhaps some consolation in the fact that No. 2 is always the same, and this is the size most generally used.

As to the strength of the solution, authorities disagree, though the author prefers to use a saturated solution, giving a glance now and then to the zincs, to see that no crystals are forming on them.

In setting up a battery, fill up the outer jar three quarters full with water, taking care not to splash the terminals; then put in as much salammoniac as will saturate the solution and leave a few crystals at the bottom.

The following are the quantities of salammoniac required to charge each cell. For a No. 1 (small size), 4 oz.; for a No. 2 (medium size), 6 oz.; and for a No. 3 (large size), 10 oz.

The battery (unless an agglomerate block) will not start at once. If the battery is required immediately, a little solution should be made in a jug, and poured into the porous pot through the opening F, having first cleared out (with a piece of wire) the air-hole A, or a small hole may be knocked in the bottom of the porous pot so that the liquid rises at once to the same level as that in the jar.

These batteries, when once set up, require little attention, and will run without recharging for a period varying between six months and two and a half years, according to the size of the battery and the amount of work it does. The battery should, however, be inspected at frequent intervals, especially in hotels,

&c., where the sudden running down of a battery is a source of great annoyance.

When inspecting a Leclanché battery the following points should be looked to: See that the salts are not creeping over the glass jar; if so, the faulty jar must be taken out, washed, well dried, and the lock rubbed with grease. See that the zincs are not eaten away, and scrape off any crystals that may have formed on them. Should the zincs be very black, while a strong smell of ammonia comes off from the porous pot, it indicates excessive working, probably a short circuit on some of the wires, which must be seen to. See that the solution has not evaporated; if so, fill up with water. If the solution is opaque or milky, add more crystals till it becomes clear again, or substitute a new solution. See that none of the solution has got on the terminals, or it will rapidly eat them away. See that no white lead is forming between the lead cap and carbon plate (see L, Fig. 70) as owing to the bad conducting power of the white lead, increased resistance is thrown into the circuit.

Fig. 74.

When recharging a Leclanché battery it will be necessary first to see if the zincs are still good and not eaten all away. If the zincs are in fair condition, renew the solution, and should this effect no improvement, new porous pots or agglomerate plates must be substituted for the old ones. Owing to the slight cost of the new porous pots, it is never advisable to attempt to recharge the old ones, which, at the best, is a difficult and tedious operation.

A modification of the Leclanché battery, which is known as "Judson's Patent," is shown in Fig. 74. Its chief novelty lies in the negative element, which, instead of being applied in the form of a plate, consists of a carbon cylinder, the inner surface of the cylinder being corrugated, as shown in the section. The outside of this cylinder is covered and made

perfectly watertight with an insulating mixture, such as Chatterton's compound. Inside the cylinder are cemented two thin carbon plates, the spaces between the plates and the inner surface of the cylinder being filled with a depolarising mixture of granulated carbon and manganese. The carbon cylinder, besides forming the negative element, also takes the place of the outer glass jar of the ordinary form, serving to contain the solution. For the positive element, a zinc rod, on the top of which is fixed a brass terminal, is suspended in the centre of the cylinder, and kept from touching the sides by rubber bands. The cell is sealed at the top, with the exception of a small air-hole, and the zinc rod is capable of being withdrawn for convenience in filling. The centre terminal is the zinc, and the other one (seen to the left of the figure) the carbon, to which it is affixed by a cast-lead band. The internal resistance of this cell is very low, owing to the large surface presented by the corrugations on the carbon cylinder, it is also very compact, and great power is capable of being got out of a small cell.

To do away with the necessity of paraffining the edges of the glass jars as a prevention against the creeping of the salts, Messrs. Gent, of Leicester, have devised a form of jar in which a recess runs round the edge, this recess being filled, after the battery has been set up, with oil, melted paraffin wax, or any material to which the salts will not adhere. This form of jar, which Messrs. Gent call their "patent insulated jar," entirely prevents all creeping of the salts, and will give a high insulation of the battery, even in the most trying situations. A complete cell fitted with one of these jars is shown in Fig. 75.

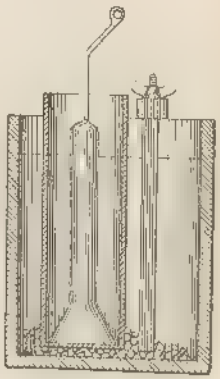
The Fuller bichromate battery, as regards its use, may be looked upon as a sort of compromise between the Leclanché and the Daniell. The Leclanché should always be employed for intermittent work, the Daniell for closed circuit work, where a constant current for long periods is required, and the Fuller bichromate in places where the work is too heavy for the Leclanché (there not being sufficient intervals of rest to allow

it to recover itself), and yet the current is not required continuously so as to warrant the employment of a Daniell.

In the "Fuller" cell (Fig. 76), for the negative element a carbon plate is employed, this plate standing in an outer glass

Fig. 75.

Fig. 76.



or stoneware jar. Inside the jar is a porous pot containing a zinc rod, which forms the positive element. Water only is used in the porous pot, while in the outer jar is placed the following solution :—

Bichromate of potash	6 oz.
Water (hot)	2 pints.
Sulphuric acid	6 oz.

The bichromate of potash should first be mixed with the water, and, when the solution is cool, the sulphuric acid added drop by drop, the mixture being constantly stirred with a glass rod.

A solution may also be made with chromic acid, by which the

strength of the battery is much increased and its constancy improved. The following makes a good chromic acid solution :—

Chromic acid crystals	1 lb.
Water (cold)	1½ pints.
Sulphuric acid	7 oz.

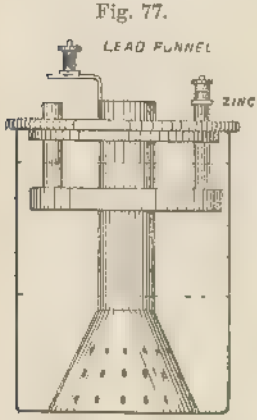
As will be seen from the figure, the zinc rod is cast cone shape at the bottom, as the base is most acted upon. Sometimes the coned part only is used, being cast on to a copper rod, but zincs of the shape shown are to be preferred, as the fluid acts on the copper rod unless well insulated. The zinc must be well amalgamated, and a couple of ounces of mercury placed in the bottom of the porous pot to keep up the amalgamation. To prevent too rapid a diffusion of the liquids, thickish porous pots should be used, the pots being paraffined all over except a band of about 2 inches at the bottom. Such a battery, if properly set up, will run for a period of from three to six months' duration (according to the amount of work it does), without attention, when the solution, and probably the zincs, will require to be renewed.

Neither of the two forms of batteries just described are any good for furnishing a current for long periods at a stretch, and when a battery is required to work continuously on closed circuit, a Daniell cell (preferably the gravity form) should be employed. For the "gravity" cell a glass jar, 12 inches high and 10 inches in diameter, should be employed, fitted with a porcelain or wood cover saturated with paraffin wax. An inverted funnel, made from 4-lb. sheet lead, stands in the centre of the jar, the bottom part of the funnel being perforated with numerous holes. A cast zinc ring, with two projecting lugs on the top, is slung from the lid of the jar, the lugs passing through two holes in the lid, and pins being slipped through to secure them. One of these lugs has a terminal fitted on the top, another terminal being also fastened to the lead funnel

To charge the cell; water, to which has been added three or four drops of sulphuric acid, is poured into the glass jar. A saturated solution of sulphate of copper is next slowly introduced into the top of the lead funnel; this solution, by virtue of gravitation, remaining at the bottom of the jar, and displacing the water upwards. Crystals of copper sulphate are then dropped into the lead funnel through the opening at the top, till the perforated part of the funnel is full.

Another method of charging the battery is as follows:—Drop copper sulphate down the neck of the funnel till it is full, and then pour in cold water till the level of the liquid is above the top of the zinc ring. The two terminals should then be joined with a piece of thick wire, so as to short-circuit the battery, the battery being kept short-circuited for about twelve hours. On inspection it will be found that copper has been deposited on the lead funnel from the sulphate, thus converting it into the copper or negative element of the battery. Care must be taken not to shake the battery when once set up.

Fig. 77.



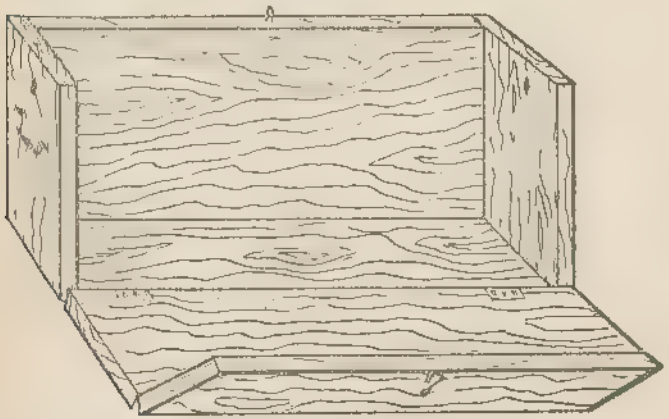
These cells will run on a closed circuit for periods of from three to five weeks without attention, and then all that they require is to have the funnel filled with copper sulphate, and some of the top liquid drawn off with a syringe and replaced with water. The zinc must also be scraped to clear off the copper that has been deposited thereon. The liquids have less tendency to diffuse if kept continually on closed circuit than when the cells are allowed intervals of rest.

Fig. 77 shows a form of the gravity cell.

All batteries should be contained in a box, and Fig. 78 shows a convenient form for this purpose. The front and lid are so

hinged that, when released, they fall over outwards into the position shown in the figure, thus allowing ready access for inspection.

Fig. 78



The Gassner cell is, like the Leclanché, suitable only for intermittent work, and should it prove itself perfectly trustworthy, must eventually become a formidable rival of the Leclanché. Being a *dry* battery it can, unlike the previously described forms, be placed in any position, and will work as well lying on its side as when standing up. The Gassner dry cell consists of a carbon plate or cylinder, forming the negative element, contained in an outer zinc case, the space between the carbon plate and zinc case being filled with a mixture of oxide of zinc and gypsum in the form of a stiffish yellow jelly that is apparently but little affected by the ordinary variations of temperature. The zinc case forms the positive element, a short length of copper wire being soldered on to it for a connection. The battery is made in both a round and flat form. As regards its comparison with the Leclanché, Mr. W. Lant Carpenter, in the conclusion of a paper read before the British Association meeting at Bath in September, 1888, on the comparison of

Gassner's dry cells with the Leclanché, says: "Considering the whole of these results, it appears that the round form of Gassner's dry cell polarises less than a No. 2 Leclanché, and is also of considerably lower internal resistance (the average value being about 0·25 ohm); further, that although the dry cell takes somewhat longer to completely recover its E.M.F. when the circuit is opened, the rate of recovery is more rapid than that of the Leclanché for the first five or ten minutes. The flat form of dry cell appears to behave, in most cases, not quite so well as a No. 2 Leclanché, the internal resistance being about the same —0·6 ohm."

The battery, when exhausted, is recharged by sending a current of two or three ampères through it for a few hours.

There is room for improvement in the terminals of the cells, the soldered wire connection being very inclined to break off, while the brass clamp connection for the carbon in the flat form seems a very rough-and-ready and old-fashioned arrangement.

In the flat form, also, the salts have a tendency to creep up the carbon plate and attack the brass clamp, destroying the connection. The eating away of the clamp, however, can be somewhat prevented by platinum pointing the clamping screw, and soldering a piece of sheet platinum inside the clamp.

As the outside zinc case forms one of the elements, care must be taken that the cells do not touch one another when connected up, or the cells will be short-circuited. To prevent this, it is as well to divide the battery box into separate compartments, one for each cell.

It is also advisable, when the battery is intended to be placed in a damp situation, to wrap up each cell separately in two or three layers of paraffined brown paper. In warm places, where the Leclanché is often an intolerable nuisance, the dry cell works to perfection. The flat form is well adapted for use in portable electric bell sets. Fig. 79 shows the flat, and Fig. 80 the round form of the Gassner dry cell.

We will now turn our attention to a few of the different ways in which cells are connected up. Each outer jar, with its two

Fig. 79

Fig. 80

elements and the liquids in which they are immersed, is known as a *cell*, and any number or combination of cells is called a

battery. Much battery power is often wasted by want of knowing how the cells may be arranged to their best advantage, which depends entirely on the resistance of the circuits and the construction and arrangement of the apparatus that they are required to work.

When the two elements of a cell are brought into contact with their exciting liquid or liquids, an electrical disturbance is set up and the positive element is raised to a higher potential than the negative. There is thus a difference of potential between the two elements which tends to produce a flow of electricity from the element of higher potential to that of the lower. This tendency to produce a flow is called *electro-motive force*, or for brevity sake E.M.F. If we connect the two terminals of the cell with a piece of copper wire, a current of electricity will flow through the wire from the negative to the positive element, and, inside the cell, through the liquid from the positive element to the negative. The terminal from which the electricity appears to start as it flows through the wire is called the *positive*, and that towards which it flows the *negative* terminal. It will be seen from this, that the positive terminal is on the negative element, and the negative terminal is fixed to the positive element, and the latter should not confuse the two, bearing in mind also that the current *always* flows (outside the cell) from the positive to the negative terminal. When the terminals of a battery are connected across by a piece of wire, the circuit is said to be *closed*; but when the wire is severed, the circuit is *open*. There are two things that impede the flow of electricity when the circuit is closed. These are; first, the resistance of the wires (as the best of conductors offer some resistance); and second, the internal resistance of the battery itself.

An analogy to the flow of electricity may to some extent be found in the flow of water in pipes. Thus, suppose a large cistern full of water is placed on the top of a building and connected by means of a pipe to an empty cistern at the bottom, a

tap being inserted in the pipe for the purpose of controlling the flow of water; then the difference of level of the two cisterns will produce a pressure, which, when the tap is turned on, causes a flow of water. When the tap is turned off, the difference of level still produces a pressure down as far as the tap, but as there is no passage for the water, no flow can take place. So with the battery, so long as the circuit is closed a flow of electricity takes place, but when the circuit is opened the flow ceases, though there is still the tendency to produce a flow consequent upon the difference of potential between the two elements.

The E.M.F. of a cell, which varies in the different kinds, is determined by the nature of the elements and exciting liquids, and is quite independent of the size of the cell. Thus the E.M.F. of a Leclanché which is 1·60 volts, is just the same for a cell of one pint capacity as for one with a capacity of ten gallons. But, although increasing the size of a cell does not increase its E.M.F., any increase in the size of a cell is accompanied by a corresponding decrease in its resistance. For in a cell, which from the surface of its elements has an internal resistance of one ohm, doubling the surface of the plates will reduce its resistance to $\frac{1}{2}$ ohm, and making them four times the size to $\frac{1}{4}$ ohm.

Ohm's law, so called from Professor G. S. Ohm, by whom it was first enunciated, determines the strength of the current in a circuit, it is *that the strength of the current varies directly as the electro-motive force, and inversely as the resistance of the circuit.* From this we see that if we want to increase the current strength in our circuit we can do so in two ways, either by increasing the E.M.F. of our battery, or (provided the battery is of low resistance) by reducing the resistance of the circuit. The standard of electro-motive force is the *volt*, and one volt is roughly the E.M.F. of a Daniell's cell. The standard of current strength is the *ampère*, and that of resistance the *ohm*. From Ohm's law we get a formula relating to current,

electro-motive force, and resistance, which is usually written as follows:—

$$\text{Current} = \frac{\text{Electro-motive force}}{\text{Resistance}},$$

for which the initials of the words are generally substituted, for brevity sake, as shown below:

$$C \quad \frac{E}{R},$$

which means, that if we divide the resistance of the circuit in ohms, into the E.M.F. in volts at which the current is supplied, the product will give the current strength in ampères. Likewise, if we know the value of any two out of the three quantities, by an application of the formula, the third can at once be found; for it is obvious that the equation $C = \frac{E}{R}$ may be written $R = \frac{E}{C}$ or $E = C \times R$.

Thus, from Ohm's law, we see that to produce one ampère of current in a circuit having one ohm resistance requires an E.M.F. of one volt. If we increase the E.M.F. to two volts without altering the resistance of the circuit, we get two amperes, and if we still further increase the E.M.F. to four volts, we get four ampères of current. Similarly, if keeping the E.M.F at one volt, as in the first instance, we reduce the resistance of the circuit to half ohm, we get a current of two ampères; and if we still further reduce the resistance to quarter ohm, we get four amperes. Going back to our analogy of the cistern and waterpipe, we will suppose the tap in the pipe to have been removed, and the water to be flowing as fast as the pipe will let it into the bottom cistern. Let us presume that the pipe is of such diameter that the water is passing a given point in the pipe at the rate of one pint per second; it is evident then, that if we wish to increase the flow of water to

two pints per second, we can do so in two ways, either by increasing the pressure so as to force the water through at double the rate, or leaving the pressure the same, we can double the area of the pipe, which will produce the same result.

The following table shows the E.M.F. and internal resistance of the different cells just described —

Name of Cell.	E.M.F in Volts.	Resistance in Ohms.
Leclanché (Porous pot) No. 1	1·60	1·13
„ „ „ 2	1·60	1·10
„ „ „ 3	1·60	·9
„ (Agglomerate) „ 1	1·55	·70
„ „ „ 2	1·55	·60
„ „ „ 3	1·55	·50
Fuller, 1 quart	1·80	·50
Gravity, 2 quarts	1·07	9·0
Gassner, round	1·47	·25
„ flat ..	1 17	[illegible]

If we wish to know what current we shall get in any circuit, we proceed thus. We first find the resistance of our circuit, which we will presume is found to be 4 ohms, including the resistance of the batteries themselves. From our table of E.M.F. and resistances of the different cells we can find the E.M.F. of our batteries, which in this case we will say is 6 volts. Now by the formula

$$C = \frac{E}{R}$$

we get, substituting the numerical values for the symbols,

$$C = \frac{6}{4}; \text{ therefore } C = 1\tfrac{1}{2} \text{ ampères.}$$

Again, if we know that our current flowing is 1½ ampères and the E.M.F. of our batteries 6 volts; what is the resistance of our circuit?

Now

$$R = \frac{E}{C} \qquad R = \frac{6}{1\frac{1}{2}} \qquad \therefore\ R = 4 \text{ ohms},$$

which, allowing 2 ohms as the resistance of the cells, gives 2 ohms as the resistance of the external circuit.

Similarly, if we know the current and resistance, we can find the E.M.F.

Thus—

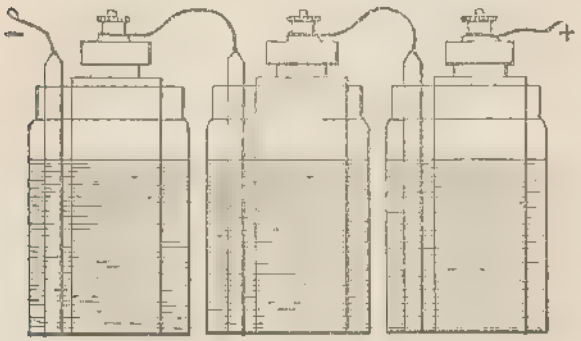
$$E = C \times R \qquad E = 1\frac{1}{2} \times 4 \qquad \therefore\ E = 6 \text{ volts}.$$

Now it is not the intention of the author to advise the fitter (after the wiring has been done and the bells and other appliances fixed) to sit down (as the electrical engineer might do when working out the size of the circuits) and go through a long mathematical calculation as to the best number and size of cells to employ, since this is wholly unnecessary; but rather that he should, by a glance at the length of his wires and an inspection of the winding of his bell coils, obtain a rough idea of the resistance of his circuits and the current he requires. If he knows the resistance the different size wires offer per yard, &c., he can easily (after reckoning up the amount of wire used) get a pretty accurate knowledge as to the resistance of his circuits. For this reason we subjoin the following approximate table, which shows the number of feet to the ohm, yards per lb., &c., of the different size copper wires.

Size of Wire, B.W.G.	Decimals of an Inch.	Yards per lb.	Ohms per 1	Number of Feet to 1 Ohm
No. 14	·083	15	·07	665
„ 16	·065	26	·19	405
„ 18	·049	45	·59	230
„ 20	·035	89	2·27	150
„ 22	·028	140	5·55	75
„ 24	·022	227	14·50	45
„ 26	·018	359	32·48	30

If his circuits are long, and the coils of his bells and indicator movements wound with fine wire, he will know that he will require a small current with a fairly high E.M.F. When, as in this case, the object is to get a high E.M.F. with a small current, the cells must be joined in *series* as in Fig. 81, which shows three Leclanché cells in series. In joining cells in

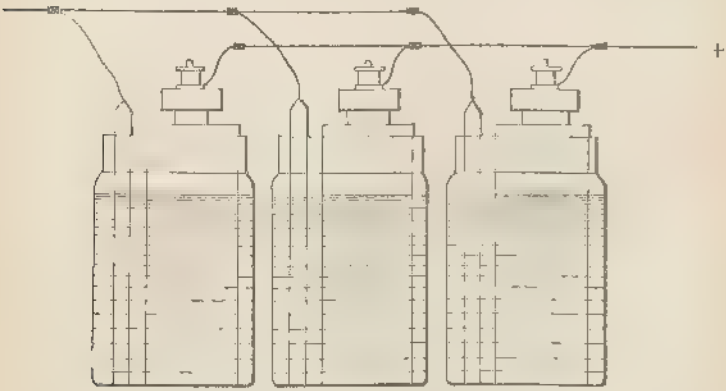
Fig. 81.



series, the carbon terminal of the first cell is left free, and the zinc of the first joined to the carbon of the second, and the zinc of the second to the carbon of the third; the zinc of the third being left free. In the case mentioned above, three cells would hardly be sufficient, six No. 2 being more like the number that would be required. As we add cell after cell to the series, so we increase the total E.M.F. of the battery by that of the cell that is added. Thus, in Fig. 81, where we have three cells in series, the E.M.F. of the battery, instead of being that of a single cell, which is 1·60 volts, is 1·60 + 1·60 + 1·60 = 4·8 volts. It must be borne in mind, however, that in adding cells to the series we also increase the internal resistance of the battery as well as the E.M.F. Thus, in Fig. 81, the resistance of the battery is three times that of a single cell, being 2·70 ohms instead of 0·9.

The current required to ring a bell depends on the size of the bell and the winding of its coils. A small bell takes perhaps only ½ ampère, while the larger bells will take from 2 to 3 ampères. If the bells to be rung are wound with thick wire, or there are many bells in parallel, the resistance of the circuits will be low, and the battery must be of low resistance also. This can be done by joining up the cells in *parallel* as in Fig. 82, which shows three cells so joined up. The resistance of the battery is much reduced by joining the cells in

Fig. 82.



parallel, the battery in Fig. 82 having only one-third the resistance of a single cell. Coupling up the cells in parallel amounts to increasing the size of the elements of a cell, and the E.M.F. of a battery so connected is only equal to the E.M.F. of a single cell. It is better, however, where possible, to use very large cells in series, in preference to coupling up a lot of small cells in parallel. It should be borne in mind that nothing is gained by stinting the battery power, and that another cell added to the battery will give more satisfaction than spending half an hour or so trying to get a delicate adjustment of the bell.

CHAPTER V.

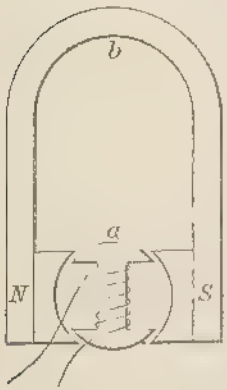
THE MAGNETO BELL.

Very often, in signalling between two places that are far apart, it is preferable, owing to the high resistance of the circuit, to employ a magneto bell and generator instead of a battery. For when the battery consists of many cells the expense becomes an important item, and there is, in addition, the bother of keeping so many cells in order. The magneto generator is generally constructed to furnish its current at a high E.M.F., such as is required on a high resistance circuit, and in telephony, magnetos are used that will easily ring a bell through a resistance of 6000 to 10,000 ohms. In large buildings, too, it is frequently desired to fit up an extra bell from one part to another without having to run wires to the battery, which may happen to be a long way off, and it is here again that a magneto may be employed to advantage. Hitherto the magneto bell has been but little used in electric bell work, its chief field being in telephony. This was due, of course, to the low resistance of the circuits in bell work as compared to those used in conjunction with telephones; but also in a great measure to the want of a convenient form of generator for fitting in houses; the ordinary form taking up too much room, besides being very unsightly. Several forms, however, suitable for house use, &c., have lately been introduced, and we shall presently describe some of them.

The apparatus required for signalling by the method mentioned above consists of two parts—the generator and the bell. The principle on which the generator acts is the same as that

on which is based the action of all dynamos, and, in fact, the generator finds in the dynamo almost its exact counterparts. The action of the generator will be readily understood by reference to Fig. 83, which shows its two principal parts, the armature (*a*), and the permanent magnet (*b*). The armature consists of an iron shuttle on which is coiled fine silk-covered copper wire. Now Faraday discovered, *that by moving a wire or other conductor near the pole of a magnet, in such a manner as to cut lines of force, a current of electricity is generated in that wire.* Thus, when the armature *a* is made to rotate rapidly between the poles of the magnet (*b*), a current of electricity circulates in its coils, the direction of the current being reversed at each half revolution of the armature. We see, therefore, that the current from the generator flows first in one direction and then in the other; the rapidity of the alternations depending on the speed at which the armature is rotated.

Fig. 83.



This alternating current is not adapted for working the ordinary form of electric bells, as these are designed to work with a current that flows always in one direction, such as is given out by a battery; so a different form of bell is used. The action of the magneto bell, which is somewhat more complicated than the ordinary form, will be better understood by a glance at Figs. 84 and 85. Fig. 85 is a side view of Fig. 84. It will be seen that the bell consists of an electro-magnet *a*, opposite the two poles of which is pivoted at *c* the soft iron armature *b*. From the centre of this armature springs the hammer *d*, which works between the two gongs *e* and *f*. By the side of the electro-magnet *a* is placed a permanent magnet *g*, the pole N of which comes near the armature *b*, and

the pole N near to the bottom yoke of the iron cores of the electro-magnet. The effect of this is, that the south pole S of the permanent magnet magnetises by induction the soft iron armature *b*, causing it to exhibit north polarity on the side

Fig. 84.

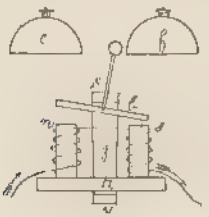
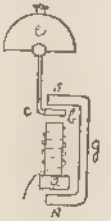


Fig. 85.

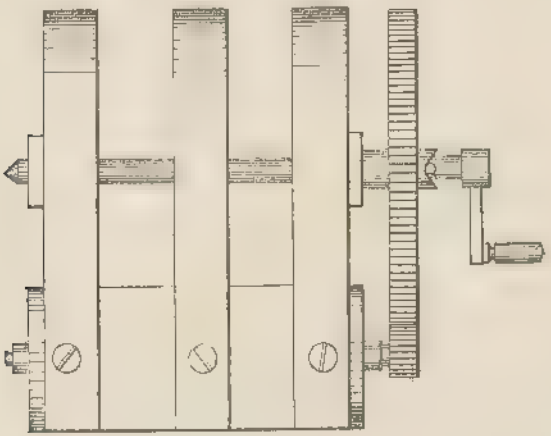


nearest to the permanent magnet but a strong south on the other. The north pole of the permanent magnet similarly magnetises the iron cores of the electro-magnet, the poles of which thus exhibit north polarity. When therefore no current is flowing round the electro-magnet, both ends of the armature are attracted alike, and the hammer will remain against either gong if once placed there. If now a current from the generator flows round the electro-magnet *a* in the direction shown by the arrows, the left-hand pole becomes north, and the right-hand south; the north pole powerfully attracting one end of the armature, and the south pole repelling the other, throwing the armature over into the opposite position shown, which causes the hammer *d* to strike the gong *e*. When, at the half revolution of the generator armature, the direction of the current is reversed, the right hand pole *b* comes north and the left hand south, throwing the armature over into the position shown, which causes the hammer *d* to strike the gong *f*. As the armature of the generator is rotated very quickly, the reversals of the current are very rapid and the ringing becomes similar to that of the ordinary electric bell. In the earlier forms of this bell, the armature, instead of being made of soft iron, consisted

of a permanent magnet; the construction of the bell being similar to that of a polarised relay. Thus, when the current from the generator was sent round the electro-magnet, its armature was alternately attracted and repelled, throwing the hammer first against one gong and then against the other. This form of bell had many defects, the chief of which were its sluggish action, and the inability of the hammer to strike the gong with sufficient force to give out a loud sound. The substitution, however, for the polarised steel armature of a soft iron one, inductively magnetised by a permanent magnet placed in close proximity to it, effected a great improvement in the bell, at once quickening its action and increasing its range.

Having thus observed the action of these bells, we can now proceed to inspect some of the different forms that they take. Fig. 86 shows a generator of the form used in telephony. The

Fig. 86.



gearing employed between the driving handle and the armature has gone through many forms. Starting originally with the ordinary cog gearing, this was renounced in favour of friction

gear, the necessary adhesion between the two wheels being obtained by placing a rubber band round each wheel. This was superseded by a special form of belting, which in turn gave

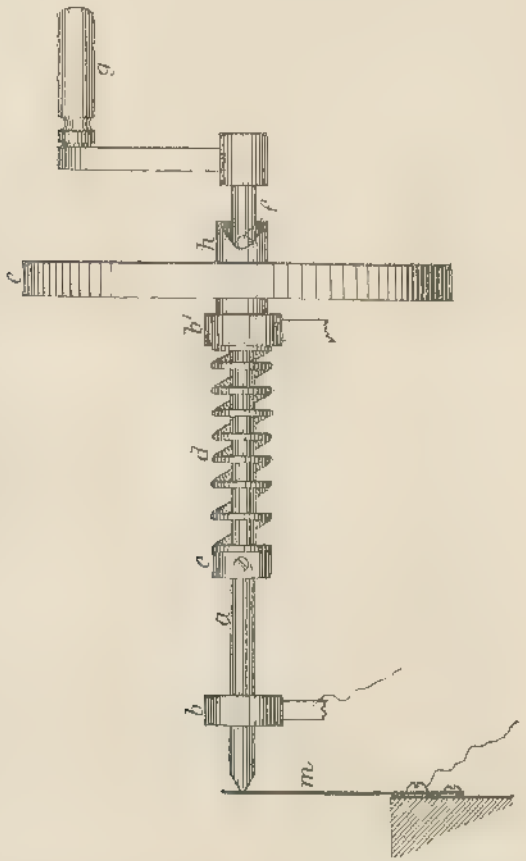


Fig. 87

way to another form of friction gear, the edge of the big wheel working in a V groove on the smaller This form, however,

was not in favour long, and a return has now been made to the original cog gearing with a special form of teeth.

The armature of the generator having a high resistance, it became a necessity (to avoid having always to ring through this resistance) to have some means of cutting out the armature when the generator was not in use. This was formerly done with a key, but an improved method has been subsequently introduced by means of which the armature, when at rest, is bridged across by a low resistance circuit, but any movement of the handle in either direction at once breaks this circuit, throwing the current of the generator to "line." Fig. 87 shows this arrangement in detail. The spindle *a*, running in the bearings *b* and *b*, carries at one end the handle *g*. The driving wheel *c* is loose upon this spindle, but is prevented from slipping round by the pin *f*. This pin fits into a V-shaped notch in the collar *h*, which is part of the wheel *c*. A collar *e* is secured to

Fig. 88

the spindle *a*, and inside this is the spiral spring *d*, which, thrusting against the bearing *b'*, keeps the end of the spindle in contact with the spring *m*. So long as the end of the spindle

presses against the spring m the armature is short circuited, but when the handle g is moved, the pin f rides up in the V shaped notch in the collar h, drawing the spindle away from the contact spring m against the pressure of the spiral spring d,

Fig. 89.

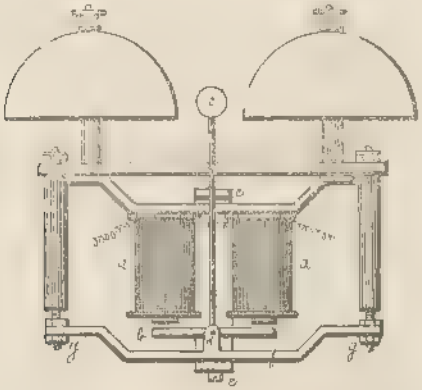
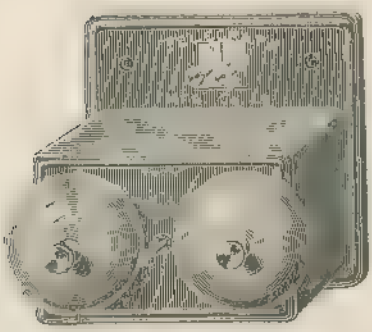


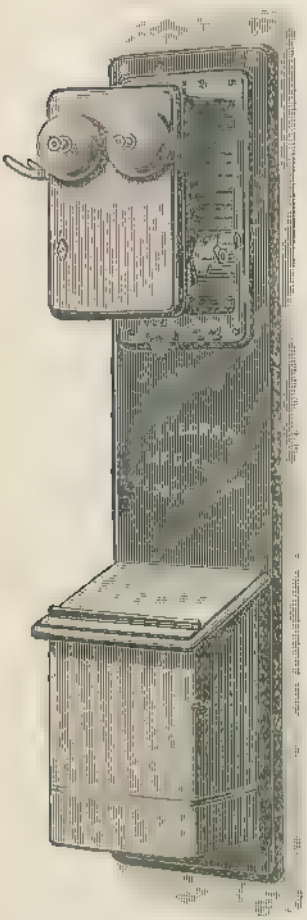
Fig. 90.



thus breaking the circuit. The generator is fixed in a walnut-wood box, as shown in Fig. 88, the handle g projecting through a hole in the side of the case. Fig. 89 shows the form of bell

generally used in conjunction with this generator; *a a* are the two electro-magnets, opposite the poles of which is the armature *b*. The hammer *c* is joined to the armature at the pivot *d*; *e* is the permanent magnet fastened to the brass piece *f*, which also carries the armature; the distance of the armature from the poles of the electro-magnet being adjusted by the nuts *g*. The bell is enclosed in a case, as shown in Fig. 90, or when it is desired to signal in both directions, placed in the same box as the generator, as shown in Fig. 91.

Fig. 91

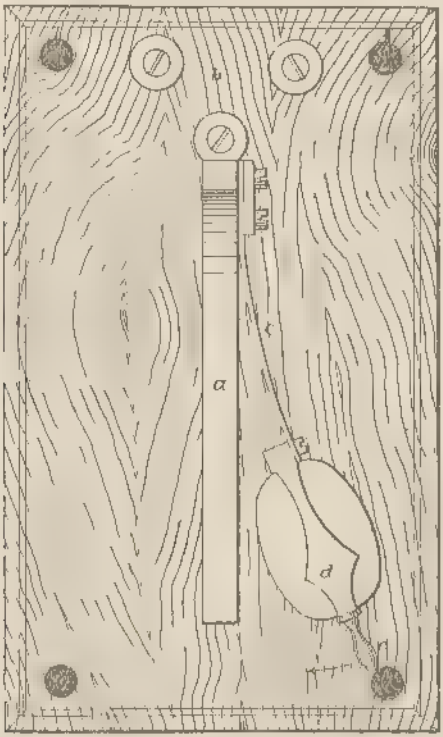


A form of the magneto call-bell, devised by M. Abdank, is shown in Figs. 92 and 93.

Fig. 92 shows the generator, which consists of a horseshoe magnet *a* fixed to the base board *b*. From the top of the magnet is suspended by means of the spring *c*, the armature *d*, consisting of a number of coils of fine wire wound round an iron core. To the bottom of the armature is fixed the handle *e*. When the armature is drawn (by means of this handle) on one side—into the position shown in the figure—and then released, it swings forward and vibrates rapidly between the poles of the magnet *a*, finally returning to its normal position, which is between the two poles. This generates

a rapidly alternating current on the bobbin, which flows to the two terminals at the top of the base. In the bell (Fig. 93) another bobbin of wire is used wound on a piece of thin sheet-iron *a* cut to the shape of the letter H. This sheet-iron is supported at the bottom by the piece of spring *b*, and at the top

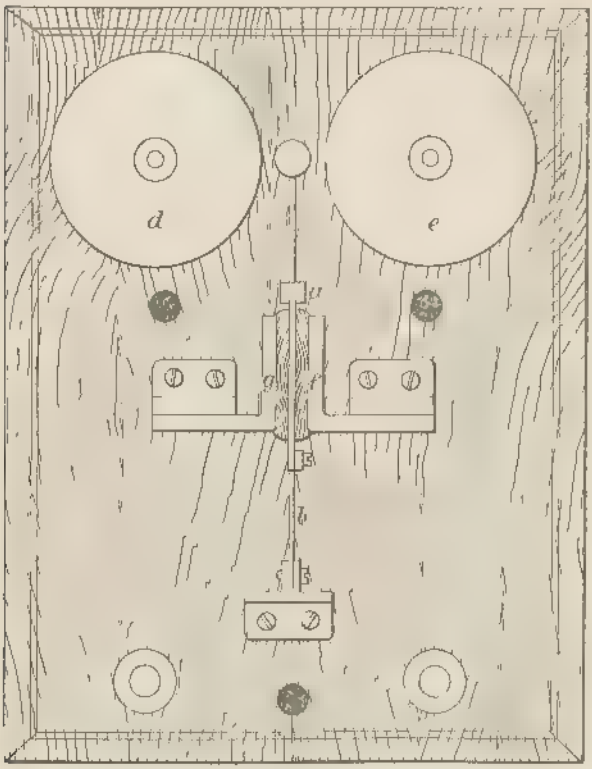
Fig. 92



carries the hammer *c*, the head of which works between the two gongs *d* and *e*. Two permanent magnets *f* and *g* are fixed one on each side of the bobbin *a*. When the current from the generator enters at the two terminals, seen at the bottom of

the bell, it passes round the bobbin, magnetising the iron core *a* and causing it to vibrate in unison with the vibrations of the armature of the generator As will be seen, the apparatus is

Fig. 93.



very simple, and can, moreover, be fixed in any position, being well adapted for call-bells in private houses, &c.

Figs. 94 and 95 show a form of magneto call-bell devised by Messrs. Cox-Walker, and Swinton. In the generator the movement of the armature is limited by stops to a quarter of a

Fig. 94.

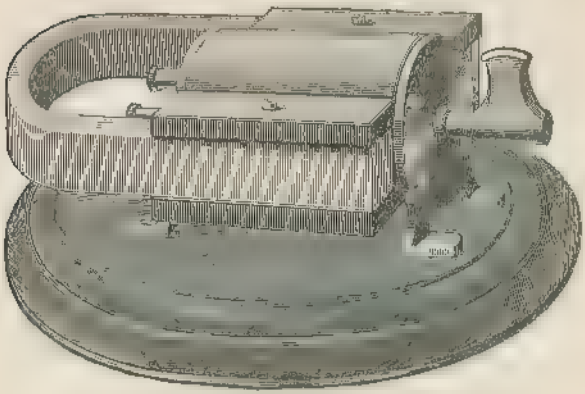
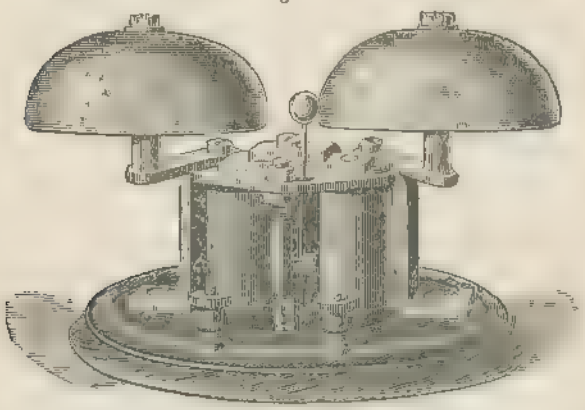


Fig. 95.

revolution, so that by catching hold of a projecting stud fixed on to the armature spindle, a current is generated in one direction by swinging it to one side, and in the other when swung to the opposite side. Fig 95 shows one form of the bell, the movement of which is all contained in the gong. The movement is similar to that shown on Fig. 89, only the hammer,

Fig. 96.



instead of striking on two gongs, strikes on two lugs fixed on to the inside of the gong; thus securing a very neat and compact form of bell. Another form of the bell is shown in Fig. 96. For signalling between two places to a prearranged code of strokes, it is well adapted, as a swing of the stud to one side gives one stroke, and a swing to the other side another.

Magnetos require but little attention to keep them in order. A few drops of oil now and then in the bearings of the generator, and the armature of the bell may require a slight adjustment from time to time. Unlike the ordinary electric bell, however, there are no contacts in the magneto, thus no trouble can arise from dirt, &c., getting between them and destroying the connection.

CHAPTER VI.

CONNECTING-UP.

The following diagrams show the various ways of connecting-up bells, indicators, &c., and though the methods most usually required are shown, nearly every building may require some little modification of the arrangements here described.

Simple bell circuit.—Fig 97 shows a simple circuit, consisting of push, battery, and bell. The cover of the push P has been removed, showing the connections to the contact-springs, one of which, for the purpose of distinction, is shown darker than the other. The bell B (shown in detail in Figs. 41 and 47) has its cover on; thus none of the movement is visible. Z and C are the respective poles of the battery D. On the two springs of the push being pressed together the current flows from the positive pole C of the battery to the terminal L, through the bell to the terminal E, and thence by the wire and push springs to the negative pole Z. Both in this and the following figures the Z or return wire is shown thicker, in order to make the diagrams clearer.

Simple bell circuit with "earth."—Fig. 98 is a simple bell circuit with earth connections, the circuit being completed between the two plates E E by the earth. The wire from the zinc of the battery, and one of the wires from the push, are fastened to the water-pipe in the manner described on page 8.

Two or more pushes to ring same bell.—Fig. 99 shows the method of connecting two or more pushes so as to ring the same bell. The pushes are here shown with their covers on, the buttons being represented by the black dots. Pressing the

button of either of the pushes *a*, *b*, *c*, *d* completes the circuit causing the bell B to ring.

Two bells to ring simultaneously from one push.—Fig. 100 shows an arrangement by means of which two bells can be rung simultaneously from one push, the bells being some distance apart, as in separate rooms. On the button of the push P being pressed in, the current flows from the positive pole C of the battery through the push, and along the wire *a* to *d*, where it divides, half (if the bells are of equal resistance) passing through the bell B, and half through the bell B. When bells are arranged parallel like this, care should be taken to insure the resistance of the coils of each bell being as near alike as possible, or else to put the bell with the lowest resistance the farthest from the battery, so that the resistance of the line compensates for its lower resistance. If there are many bells, care must also be taken to provide sufficient battery power, the largest sized cells being used. The practice of splitting up a battery of smaller cells into two halves, and connecting the halves parallel, is not advocated unless absolutely necessary, it being far preferable to employ larger sized cells.

Two bells in separate rooms, either of which can be rung singly by means of a switch.—Fig. 101 shows a similar arrangement to that in the previous figure, only each bell is rung singly the bells being, as before, in separate rooms. A three-point switch, W, of the form shown in Fig. 38, is used, being fixed near the push P. If the button of the push is pressed while the arm D of the switch W is in the position shown, the terminal *a* is connected to *c*, and the bell B will ring, but if the arm of the switch is moved over to the opposite side, the terminal *a* is connected to *b*, and if the push is now pressed the bell B' will ring instead.

Bells in series.—Fig. 102 shows how bells are connected in series, so that by pressing the push P the bells B^1, B^2, and B^3, can be rung simultaneously. The bells, to ring satisfactorily, must be either single stroke or of the form shown in Fig. 13.

Fig 97

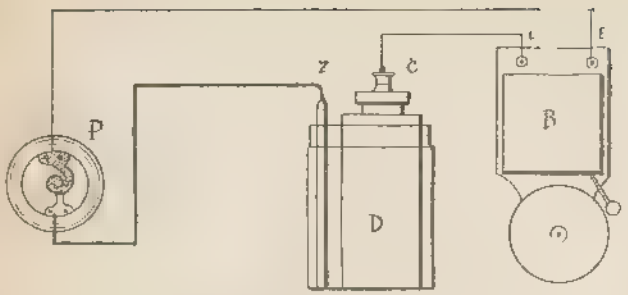


Fig 98

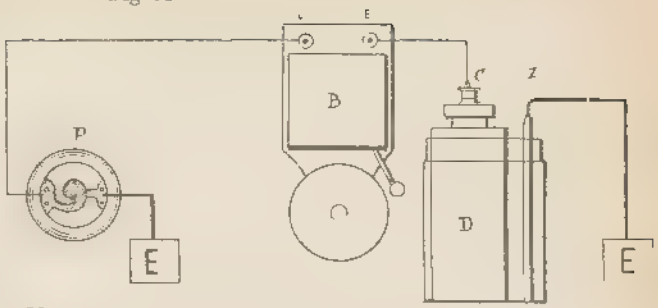


Fig 99

Fig. 100

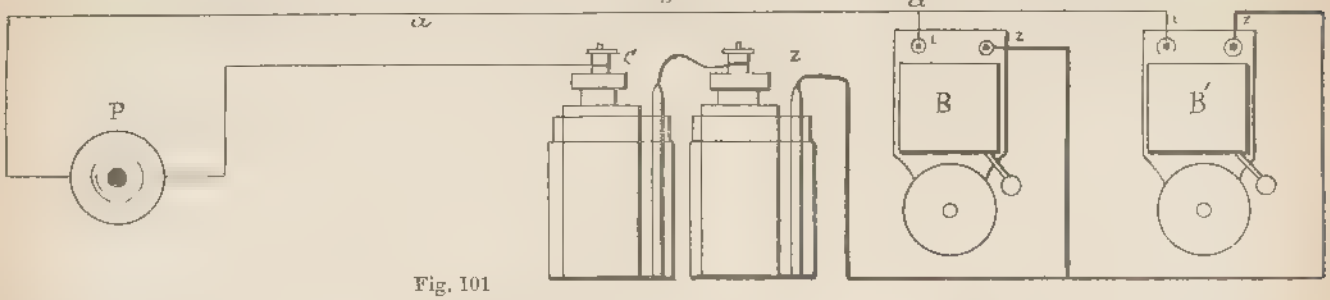


Fig. 101

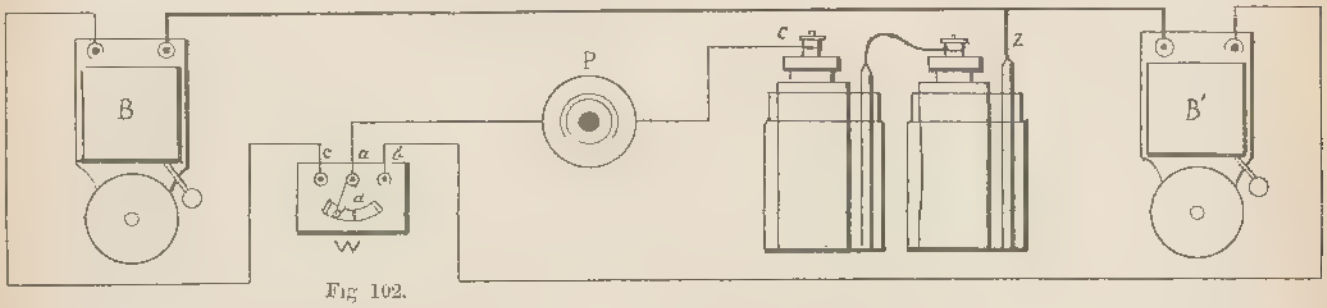
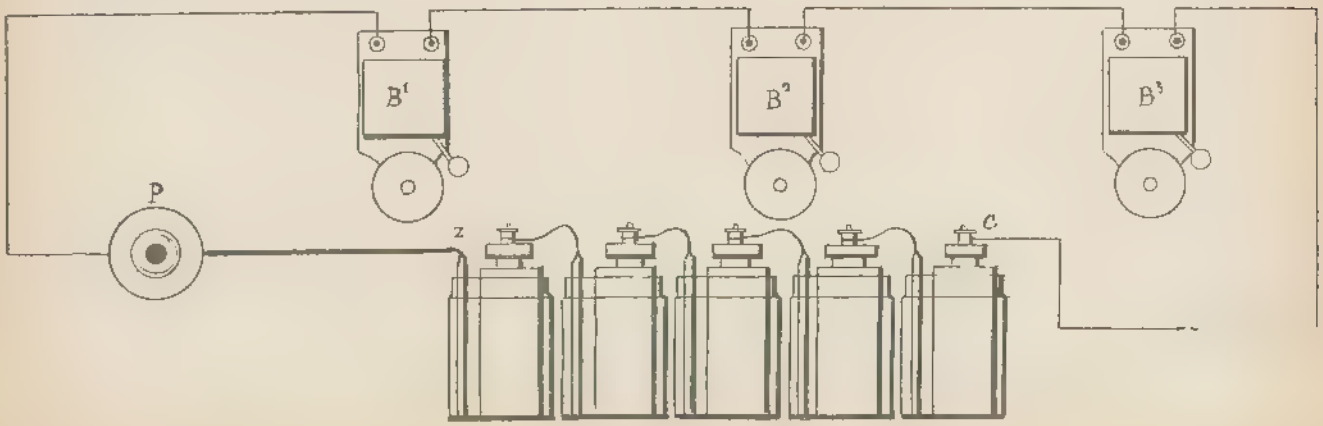


Fig. 102.



To face page 92.

The cells of the battery for this purpose (the size of which cells will vary according to the size and construction of the bells used) must be of sufficient number, connected in series, so as to obtain the E.M.F. necessary to force the required current through the high resistance necessitated by placing the bells in series.

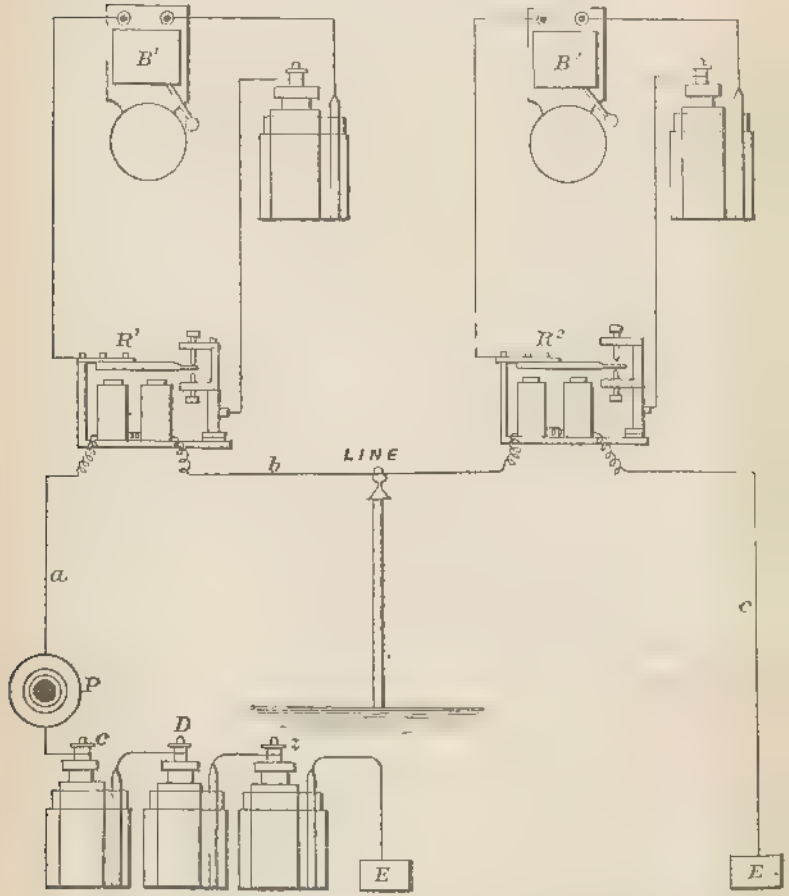
Simple bell circuit with relay. Fig. 103 shows an arrangement suitable for long distances, a relay being used to close the local bell circuit. The zinc of the battery and one of the wires from the relay are put to earth. When the button of the push P is pressed in, the current flows from the positive pole C of the battery D, through the push to the wire *a*, and from there through the relay coils to earth. The armature of the relay is thus attracted, closing the local bell circuit; the current flowing from the pole C of the local battery D through the bell to the insulated post P of the relay (see Fig. 58, page 47), and thence by the armature A and wire to the negative pole Z; the armature of the relay remaining down so long as the button of the push is kept in.

Ringing a number of bells by means of relays in series. Fig. 104 shows how a number of bells may be rung simultaneously by employing relays to close the local circuit. When the button of the push P is pressed, the current flows from the pole *c* of the battery D to push P, and through the wire *a* to relay R. Through the relay coils of relay R to wire *b*, and relay coils of relay R^1, and thence by wire *c* to earth; the other pole of the battery D being also put to earth. This attracts the armature of both relays, closing the circuits of both bells B and B^1. So long as the circuit through the push P is kept closed, the armatures of the relays are held down, and the bells ring; any break and make of the circuit being exactly reproduced by the relays.

Two sets of pushes working three bells by means of relays. — Fig. 105 shows an arrangement in which there are two sets of pushes and three bells. Any push out of one set, will ring

one bell, and any push out of the other set another bell, the third bell being common to both sets of pushes. Thus pushes

Fig. 104.



A A A ring bells A and C, by means of the relay R A, while pushes B B B ring bells B and C by means of the relay

R B. When the pushes B B B are pressed a current flows from battery No. 2 through the coils of relay B B, which thus attracts its armature, throwing the current from battery No. 1

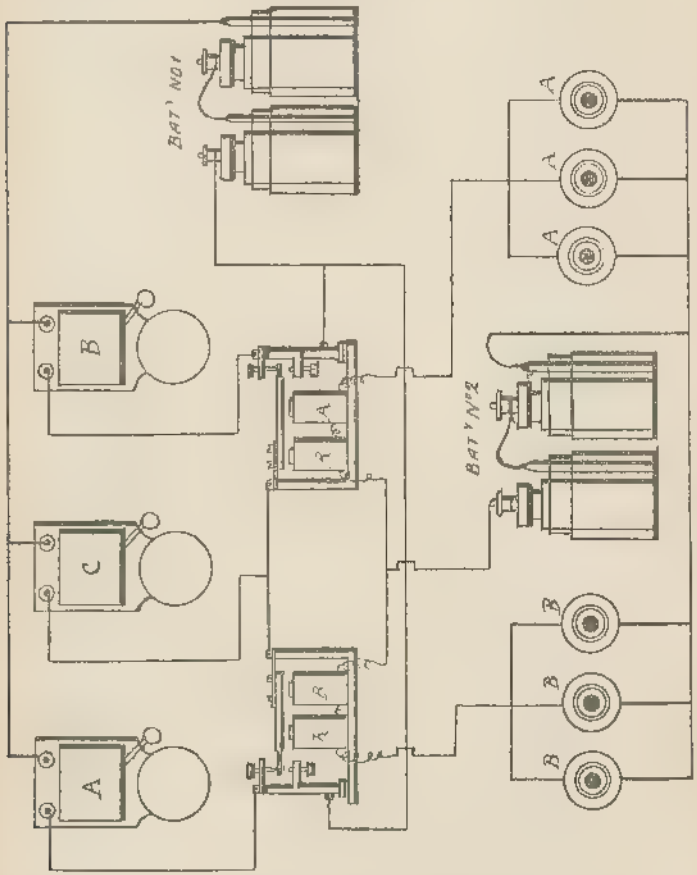


Fig. 105

on to bells B and C. The same action takes place when the pushes A A A are pressed, only with relay R A and bells A and C. Where one push only is required the arrangement

shown in the following figure should be adopted, which does not necessitate relays.

Three bells and two pushes, each push ringing two of the bells,

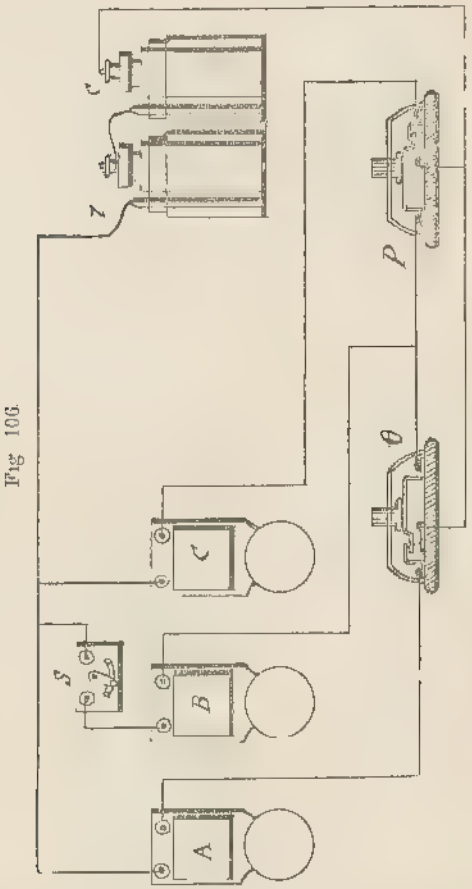


Fig. 106.

one bell being common to both pushes, which bell can be cut out with a switch.—Fig. 106 shows an arrangement in which push P

will ring bells C and B, while push P rings bells A and B, but when the arm of the switch S is moved over to the opposite side to that shown in the figure, the bell B is cut out, push P ringing bell A by itself, and push O bell C by itself. Double contact pushes or Morse keys must be used for closing the circuits

Continuous ringing bell. Fig. 107 shows the method of connecting up the continuous ringing bells shown in Figs. 44 and 45. On closing the circuit by pressing the push P, the current flows from the pole C of the battery D to the terminal C of the bell, through the bell coils to L, and thence by the wire and push to the zinc of the battery. The lever G being released on the first stroke of the bell, the local circuit through the bell is closed, the current flowing from C of the battery to terminal C of the bell, through the bell to terminal Z, and thence by the wire to zinc of the battery, the bell continuing to ring until stopped by pulling the cord W.

Continuous ringing bell with earth and local battery. Fig. 108 shows the connections for a continuous ringing bell when the circuit is very long, the ringing of the bell being continued after the original circuit is broken, by a local battery. The current in the main circuit flows (when the push is pressed) from the pole C of the battery D, by the push and wire to terminal L of the bell, and then through the coils to terminal Z and earth, the other pole, the battery, being also put to earth. The local circuit, after the bell is once started, runs from C of the local battery D to the terminal C, through the bell to terminal Z, and then by the return wire to the zinc of the battery, the bell continuing to ring until stopped in the manner previously described.

Bell made continuous ringing by an attachment to indicator movement.—Fig. 109 shows how an ordinary bell can be made to ring continuously by using an indicator constructed for such a purpose. Fig. 110 shows the indicator in detail: P P are the poles of the electro-magnet E, provided with an armature A, which when at rest is kept off the poles by the spring S. To

the frame F is fixed the pillar M, the upper end of which carries the arm N, in its normal position supported by the catch T. A contact post, R, fitted with a platinum pointed screw, V, is also fixed to the frame F but insulated therefrom by the washers *e e*. When a current flows through the coils of the electro-magnet, the armature is attracted, and the lever N slips off the catch T, causing the contact spring B to make contact with the screw V, thus connecting the insulated post, R, to the frame. The arm N (the face of which is painted white so as to show through the perforation in the dial of the indicator) is reset by pulling a cord at the side, which throws up the arm, causing it to again engage with the catch.

When the push P Fig. 109, is pressed, the current flows from C of the battery to the frame F of the indicator; thence, by screw J and wire, through the coils of the electro-magnet (attracting the armature and releasing the arm) and then by wire and push to the zinc of the battery. The current now flows from C of the battery to the frame of the indicator, pillar M, arm N, contact post R, thence by wire to the terminal L of the bell, through the bell to terminal Z and then by the wire to the zinc of the battery, the bell continuing to ring until the indicator is reset.

Callow's continuous ringing attachment for electric bells.—In Callow's continuous ringing attachment for electric bells, which was referred to on page 38 an ordinary relay is used in place of the drop relay shown in Fig. 45, page 36. This is connected to the bell, in the usual way, but with this addition—the coil of the relay is so connected as to form a shunt circuit across the terminals of the bell. It will be seen from this, that on the armature of the relay being attracted and a current flowing through the bell, part of the current is shunted through the relay, thus keeping the circuit closed. In adapting this attachment to bells already working with a relay, the relay is wound with two wires, the primary or first layer being connected direct to line, and the secondary or second layer in the

Fig. 103

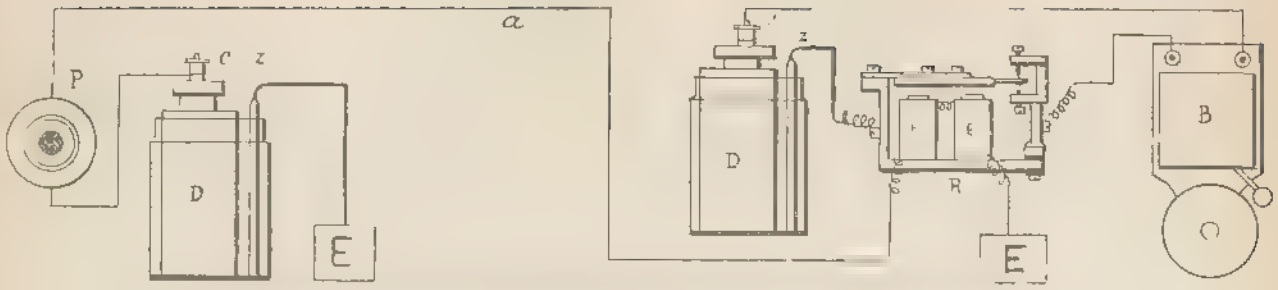


Fig. 107.

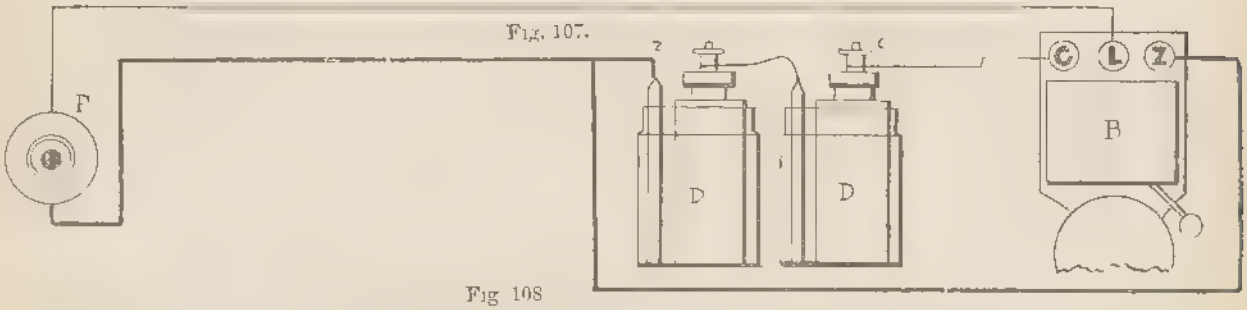


Fig 108

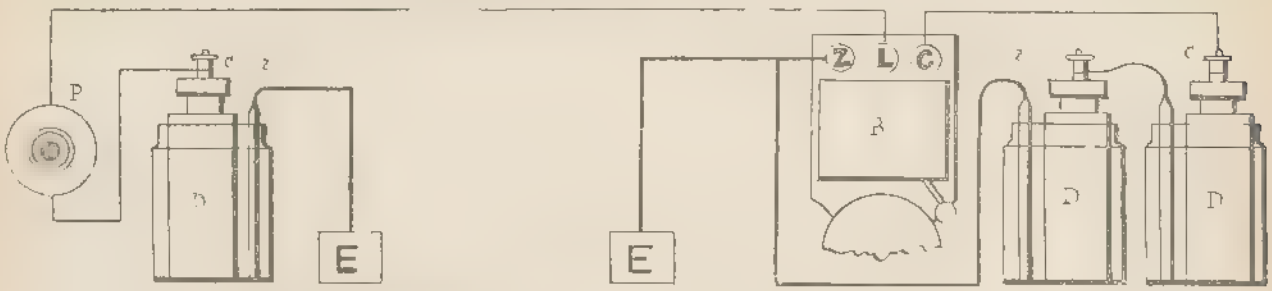


Fig 109

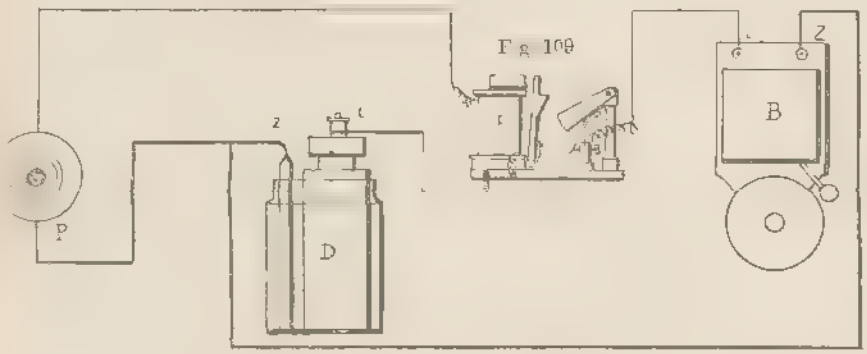


Fig 110

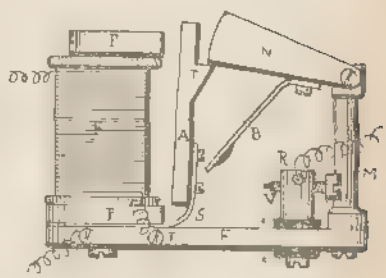
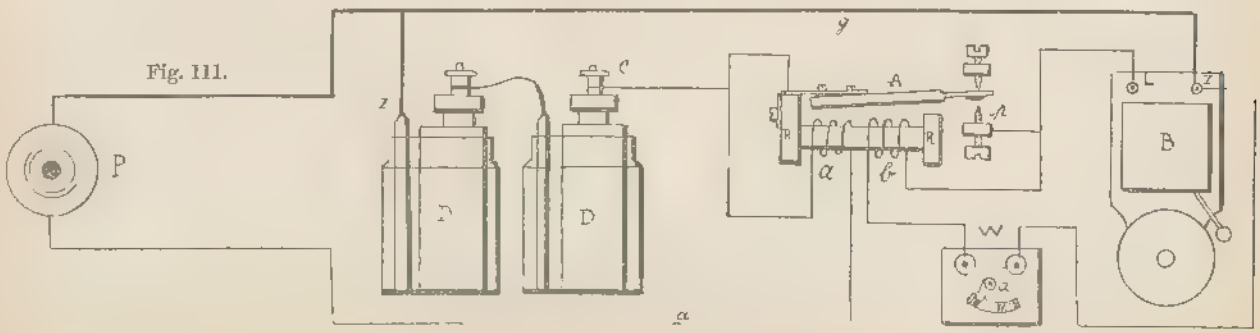


Fig. 111.



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shunt circuit. This arrangement is shown in Fig 111. When the button of the push P is pressed, the current in the main circuit flows from the positive pole C of the battery D, through the coil *a*, and thence by the wire *d* and push P to the zinc of the battery. This attracts the armature A of the relay R, closing the local bell circuit, the current flowing from C of the battery to armature A of the relay R, contact post *p*, terminal L of the bell, through the bell to terminal Z, and thence by wire *g* to the zinc of the battery. Part of the current also flows along the wire from the bell terminal L, through the relay coil *b* and switch W, to terminal Z of the bell, thus keeping the armature of the relay down after the main circuit has been broken, the bell continuing to ring until the shunt circuit is broken by moving the arm *a* of the switch W over to the opposite side. The bell can also be stopped by short circuiting the relay, which can be effected by an ordinary push

It will be seen that more than one bell can be rung from the same attachment, and the bell can, by moving the arm of the switch W, be made continuous ringing or not, at will. If the arm *a* of the switch is moved over to the opposite side to which it is shown in the figure, the shunt circuit of the bell through the relay is broken and the bell will ring only so long as the button of the push is kept in. This continuous ringing attachment is very convenient for front doors, etc., where trouble is often experienced in securing immediate attention to the summons. Instead of being taken to the switch as in Fig. 111, the two wires are taken to a contact (see Fig. 117) fixed on the side of the door frame, and so arranged that, when the door is opened, it either short-circuits or breaks the shunt circuit; thus, when the push is pressed, the bell rings until the door is opened, the continued ringing of the bell insuring prompt attention.

Bell ringing either as a vibrating or single-stroke one.—Fig. 112 shows an arrangement in which, by means of a switch fixed near the push, the bell can be made vibrating or single-stroke at will. The bell B (shown with its cover removed) is

an ordinary vibrating bell, but with an additional terminal, S, fixed between the original terminals and connected to the frame F (see Fig 41) by the screw J. If the push is pressed while the arm *a* of the switch W is in the position shown, the bell will ring as a vibrating bell; the current flowing from the pole C of the battery to terminal L of the bell, through the bell coils E E to contact post P and terminal Z, thence by wire *d* to terminal *b* of the switch, and from there by arm *a*, wire *g*, and push P to the zinc of the battery. If the arm of the switch is moved over to the opposite side, and the push pressed, the bell will ring as a single-stroke bell; the current now flowing from C of the battery to terminal L, through the bell coils to screw J and terminal S, thence by wire *f* to the terminal *c* of the switch, and from there by arm *a* and push P to the zinc of the battery. The bridge *n* in the wire *a* indicates that the wire *d* passes over the wire *g*, and is not connected to it in any way.

Signalling in both directions with three wires and one battery.—Fig. 113 shows how the bells and pushes must be arranged for signalling in both directions with three wires and one battery. Pressing the push P rings bell B, while pressing push P′ rings bell B. The circuit (when the push P is pressed) is from the pole C of the battery, wire *a*, push P, wire *b*, bell B, and zinc of the battery. The circuit through the other push is from the pole C of the battery, wire *a*, bell B′, wire *c*, push P, and zinc of the battery.

Signalling in both directions with one wire and two batteries.—Fig. 114 shows an arrangement for signalling in both directions with one wire and two batteries, double contact pushes of the form shown in Fig. 17, being used. Pressing push P causes bell B to ring, and the bell B is rung by pressing the push P′. The wire marked "line" is the wire which (taken overhead or underground) runs between the two stations. Having looked at Fig. 17, and read the description on page 16, it will be seen, on referring again to Fig. 114, that pressing the button

Fig. 112.

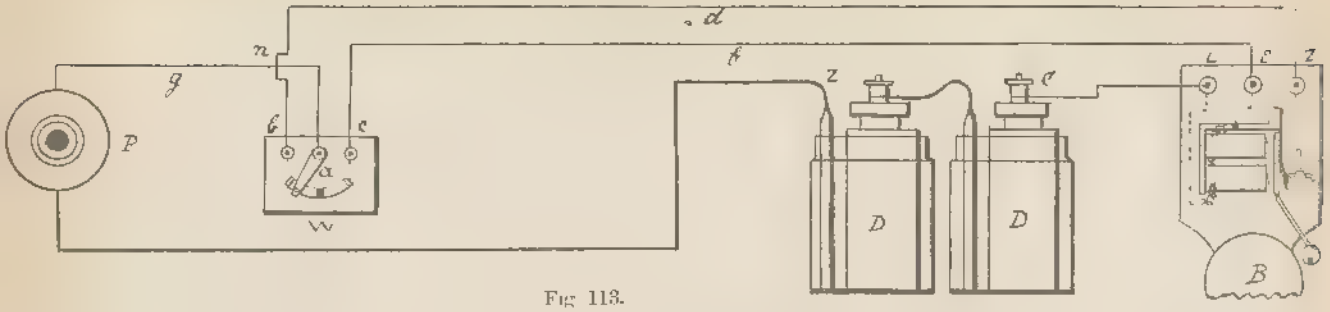
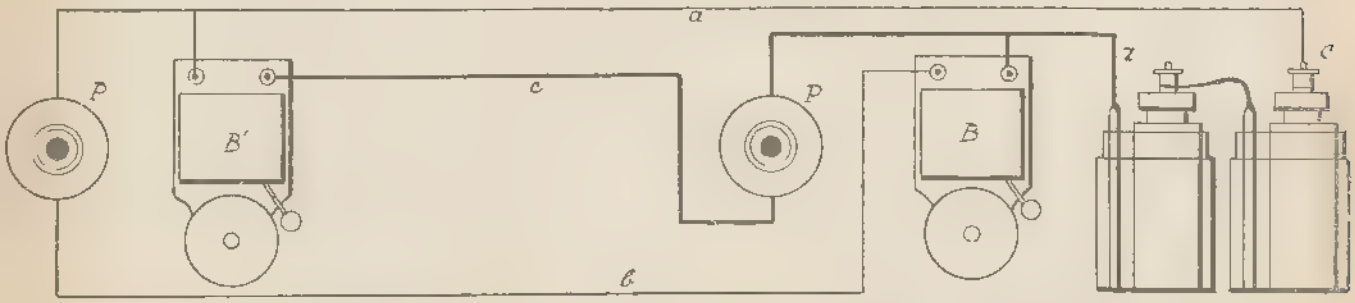
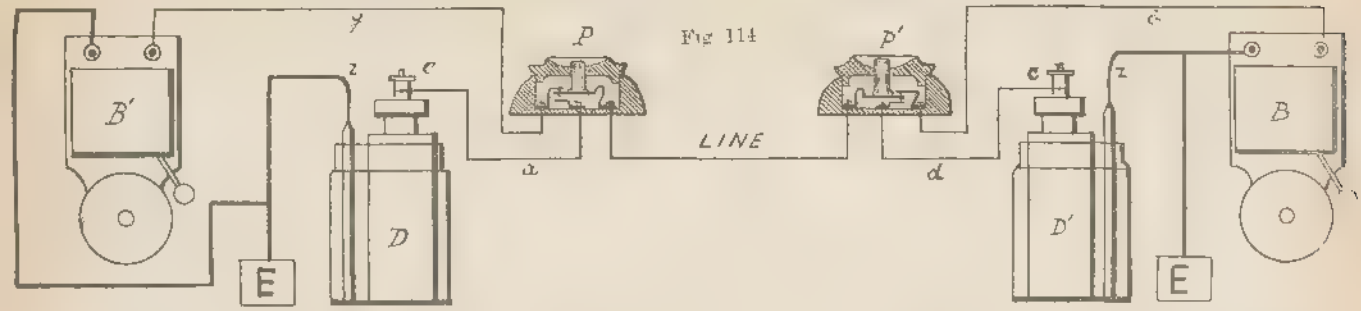


Fig. 113.





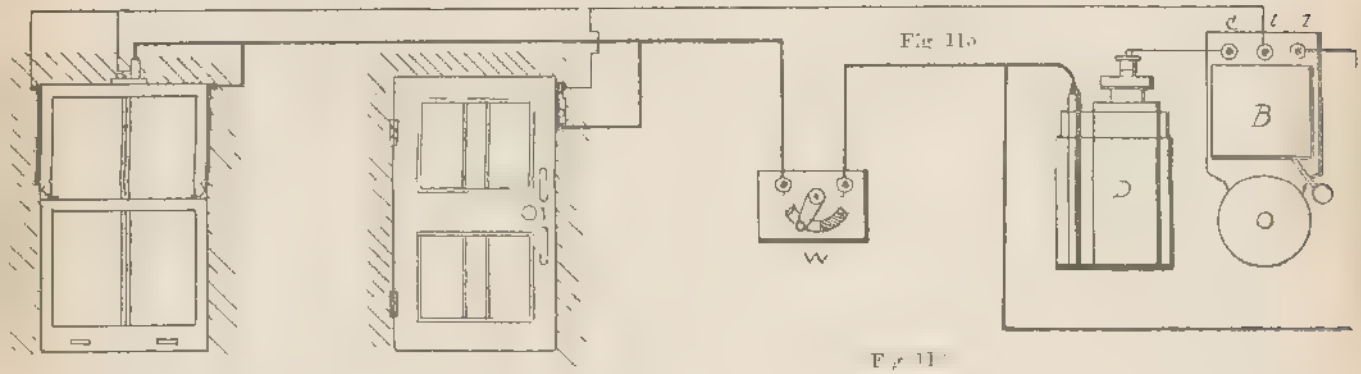
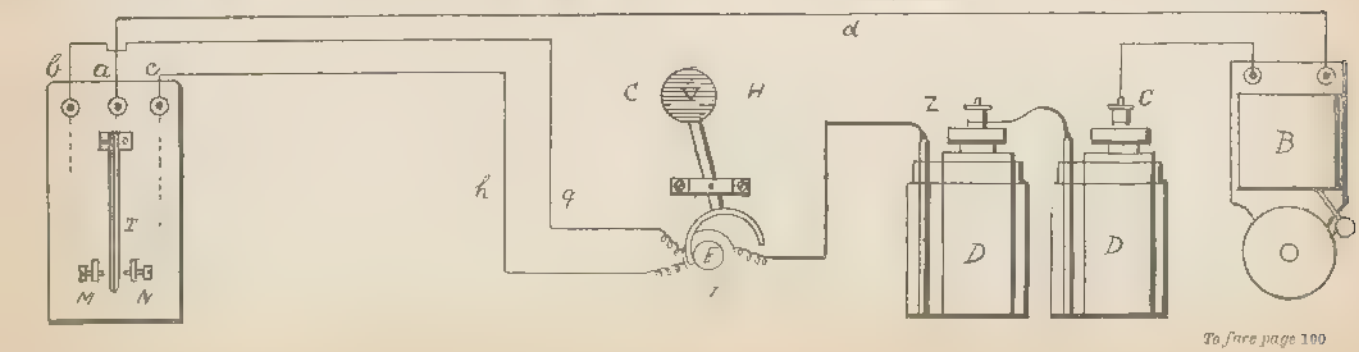


Fig 116



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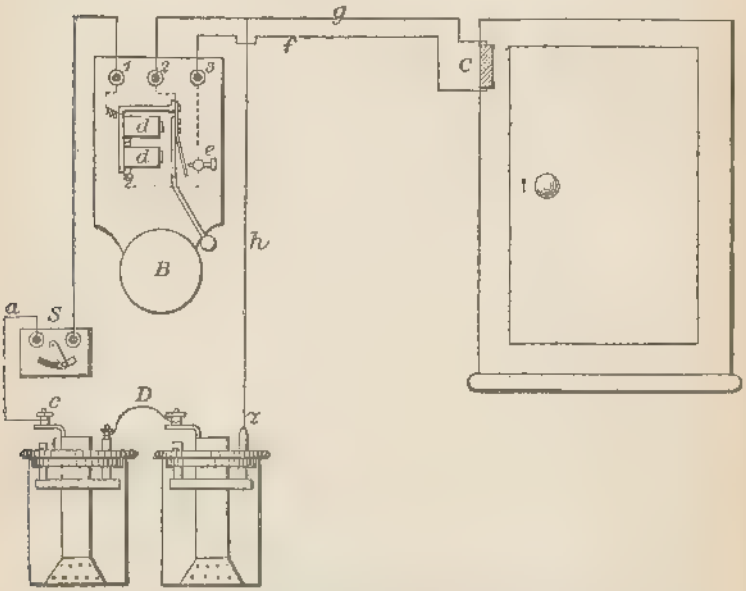
of push P puts the positive pole L of the battery D to line, the circuit through bell B being as follows: Pole C of the battery D, wire *a*, bottom contact and spring of push P, line, spring, and top contact of push P', wire *b*, bell, and earth; the other pole of the battery being also put to earth. The circuit closed by pressing push P', is from battery D, wire *d*, bottom contact and spring of push P', line, spring, and top contact of the push P, wire *g*, bell and earth, the other pole of the battery D' being likewise put to earth. A Morse key is frequently used instead of the push shown, though, of the two, for general purposes, a good substantially made double contact push is much to be preferred.

Connecting-up burglar alarm contacts. Fig. 115 shows how burglar-alarm door and window contacts should be connected-up, a window and door being shown so connected. The door is protected by a contact of the form shown in Fig. 27, the top sash by the form shown in Fig. 24, and the bottom sash by the form shown in Fig. 26. Opening either the window or the door closes the circuit, causing the bell to ring; the action that takes place being the same as that described for Fig. 107. The switch shown at W is for the purpose of breaking the circuit in the daytime, so that the ordinary opening and shutting of the windows will not ring the alarm bell. By a slight addition to the hall clock, it may be made to break the circuit in the day and close it again at night, thus doing away with the necessity for a switch, which is very often liable to be forgotten. A modification of this arrangement (Fig. 115) is much used in factories, &c., to insure all the windows being shut before the premises are closed for the night. Instead of the continuous ringing bell shown in the figure being used, a small vibrating bell is substituted. The bell will ring, should any of the windows be open, when, as a test, the arm of the switch W is moved into the position shown.

Closed circuit ringing, without relay.—A better means, however,

of protecting the windows and doors than by the method shown in Fig. 115 can be obtained by employing what is known as the "closed circuit system." It will be seen by glancing at Fig. 115, that if either of the wires leading to the contact on the door are cut or otherwise severed, the contact on that door is rendered quite useless, and the door can be opened and shut without in any way affecting the alarm bell. But on the closed circuit system, as the alarm bell is started by opening the circuit, any cutting of the wires at once starts the bell, giving an alarm. There are two different ways in which the closed

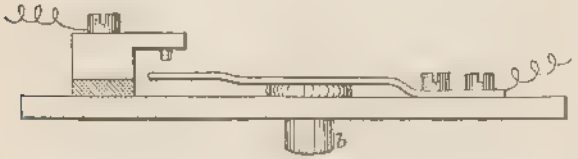
Fig. 116.



circuit system may be caused to give the alarm, 1st, by employing a special bell, working off the same battery as that which works the contact, or 2nd by employing a relay and a continuous ringing bell, worked by a local battery. Fig. 116 shows

a safe fitted with a burglar alarm on the closed circuit system, by the first method. In the figure, D is the battery (a gravity Daniell), C the burglar contact on the safe, S the switch for cutting off the alarms when not required, and B the bell. This bell is an ordinary vibrating bell, fitted with a third terminal on the right hand side of the base, which terminal is connected to the contact post *e*. A special form of burglar contact is used (shown in detail in Fig. 117) which *breaks* and

Fig. 117.

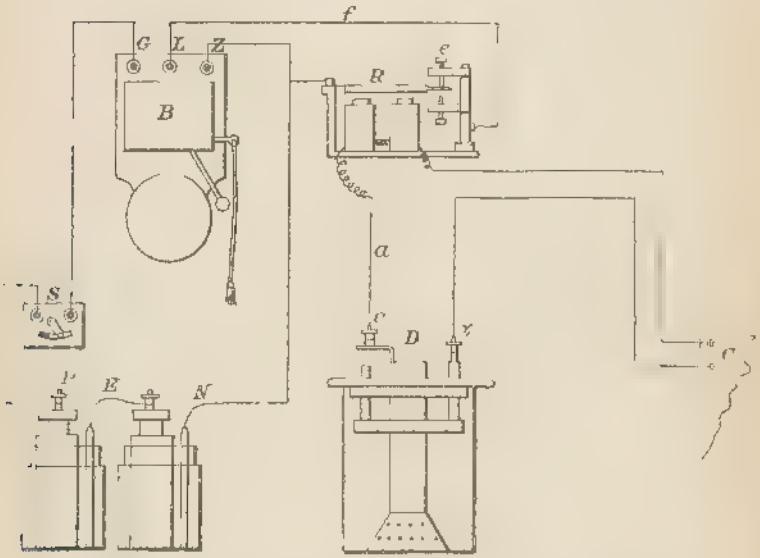


not *makes*, the circuit when the pressure is removed from the button *b*. So long as the circuit through the contact C is closed a current flows from the pole C of the battery D to wire *d* and switch S, and then through the switch to terminal 1 of the bell. From this terminal it flows through the magnet coils *d*, to contact post *e*, terminal 3, wire *f*, contact *c*, wire *g*, to the zinc of the battery. This magnetises the magnet cores, causing them to attract the armature of the bell, holding it against the poles. Thus the armature is pulled away from the contact post, and retained in that position until the circuit is broken by the safe door being opened, or the wires to the contact severed. When this takes place the armature of the bell falls back against contact post *e*, the bell continuing to ring until the switch W is moved. The circuit through the bell is as follows: Pole C of the battery D, terminal 1 of the bell, through the bell coils to contact post *e*, armature, terminal 2, and by wire *h* to the zinc of the battery.

Closed circuit ringing with relay. Fig. 118 shows a safe fitted with a burglar alarm on the closed circuit system, by the second

method. R is the relay, D the main battery (a gravity Daniell), and C the contact on the safe, E is the local battery (Leclanché). B the bell, fitted with a continuous ringing attachment, and S

Fig 118.



the switch for cutting of the alarm bell. When the door of the safe is shut the circuit is as follows —Pole *c* of the battery D, wire *a*, relay coils, wire *b*, contact *e* and zinc of the battery. This attracts the armature of the relay, causing it to break contact with the contact screw *e*. If now the circuit is broken the armature is released and makes contact with the screw *e*, which closes the local bell circuit, the current flowing from the positive pole P of the battery E, to switch S, terminal G of bell B, through the bell to terminal L, wire *f*, armature of relay, contact screw *e*, to negative pole N of the battery. This

releases the catch on the lever of the bell B, which continues to ring until the switch is shut off.

This last described method is to be preferred to the former, as it will be seen on inspecting Fig. 116 that the alarm bell will cease ringing if the safe door is closed again, which is not the case in the second method. The advantage of the *closed* over the *open* circuit system is very great. In the "open circuit," the only means of knowing whether each contact is in order, is by actually testing each one, but in the "closed circuit," should the contact fail to close the circuit when the door or window is shut, an alarm is immediately given. It is often recommended to leave the wires exposed to view as much as possible in the closed circuit system, as it is very probable that the burglar would make a point of cutting all suspicious looking wires he came across, and so giving an alarm. But, it is obvious, that if he can cut, he can also join them together, thus rendering the contact useless. Therefore, if only one system is used, it is always best to carefully conceal the wires. The most perfect alarm is obtained by combining the two systems, *id est*, having two contacts on each door or window, one contact on the closed, and the other on the open circuit system. Then, if the wires are exposed to view, an alarm will be given whether the wires are cut or short circuited. It will be noticed that in the closed circuit the different contacts must be placed in *series* and not in *parallel*, as in the open circuit system.

Connecting up hothouse alarm.—Fig. 119 shows a method of connecting up the hothouse alarm shown in Fig. 35. The indicator I (the electro-magnet E of which is wound with two coils) is included in the circuit, in order to show whether the bell rings, because the house is too hot or too cold. The indicator is shown in detail in Fig. 60. The bell, battery, and indicator, are generally fixed in the attendant's cottage. The action of the alarm is as follows:—When the temperature falls below a predetermined point, the tongue T touches the contact screw M, closing the circuit, the current flowing from the pole

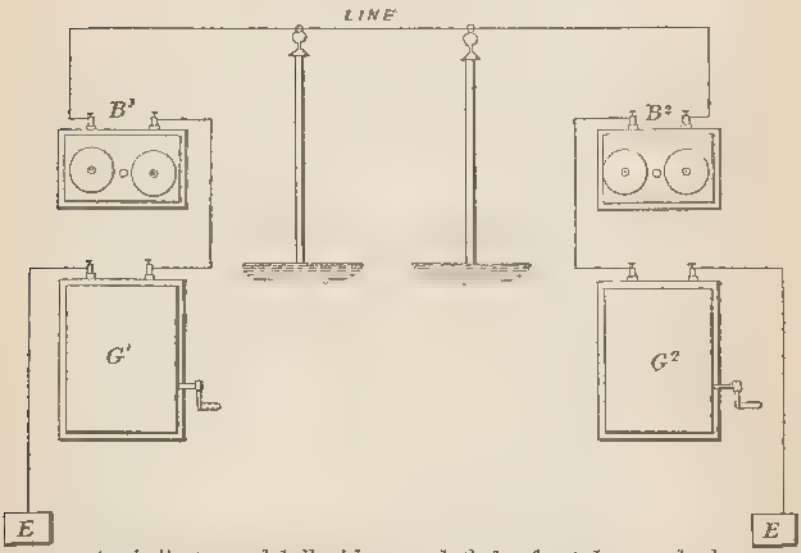
C of the battery D, through the bell to wire *d*, terminal *a* of the alarm, tongue T, contact screw M, terminal *b*, wire *g*, one of the coils of the electro-magnet E (throwing the vane over into the position shown), and then to the zinc of the battery. Any rise in the temperature causes the tongue T to touch the contact screw N, closing the other circuit; the current now flowing from the pole C of the battery to the terminal *a* of the alarm as before, tongue T contact screw N, terminal *c*, wire *h*, through the other coil of the electro-magnet E (throwing the vane over to the opposite side), and then to the zinc of the battery. Two bells of different tone are sometimes employed instead of the indicator shown, or the alarm may be made to act direct on to the ventilating apparatus.

Connecting up two magnetos. Fig. 120 shows how two magnetos should be connected-up. One terminal of each generator is put to earth, the other being connected to one terminal of the bell. The other terminal of the bell is put to line. Thus when the handle of generator G is turned, the current flows from the armature of the generator to bell No. 1, line, bell No. 2, generator No. 2, to earth, and from earth back to the armature of the generator, there being a current first in one direction and then in the other. The same action takes place when the handle of generator No. 2 is turned. Both bells ring when the handle of either generator is turned, the bells being in series. Any number of magneto bells, provided the generator is strong enough, can be placed in series, without the ringing of the one interfering with that of the others.

Connections for indicator.—Fig. 121 shows the connections for the indicator shown in Fig. 65. The circuit through the indicator when either of the pushes P^1, P^2, P^3, &c., are pressed is from the pole C of the battery, through the relay coils, magnet coils of the movement corresponding to the push that is pressed, push, and then by the return wire to the zinc of the battery. The armature of the relay being thus attracted, the circuit through the bell is from C of the battery to bell,

terminal B of the indicator, relay armature, contact screw, terminal Z, and zinc of the battery.

Fig. 120



An indicator and bell with extra bell for front door push, the front door push ringing either one bell or two by means of a switch

Figs. 122 and 123 show two methods by means of which the push T may be made, in the daytime to ring both bells A and B, but at night only A. In Fig. 122 the pushes P^1, P^2, P^3, will in the daytime also ring top bell A, but in Fig. 123 they do not In both diagrams A is the bell at the top of the house, H the indicator, and B the bell, working in conjunction with it. P^1, P^2, P^3 are the house pushes, and T the push at the hall door. When the arm of the switch S. is in the position shown, bells A and B will ring if the push T is pressed; but they will also ring if pushes P^1, P^2, P^3 are pressed. If the arm of the switch is moved over to the other side, push T, will only ring A, and pushes P^1 P^2, P^3, only B. In Fig 123, however, if the arm of the

Fig. 122.

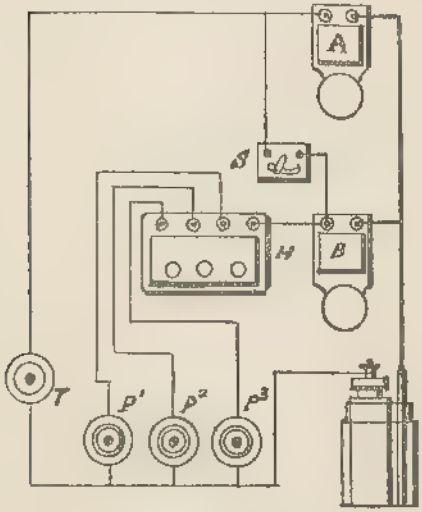


Fig. 123.

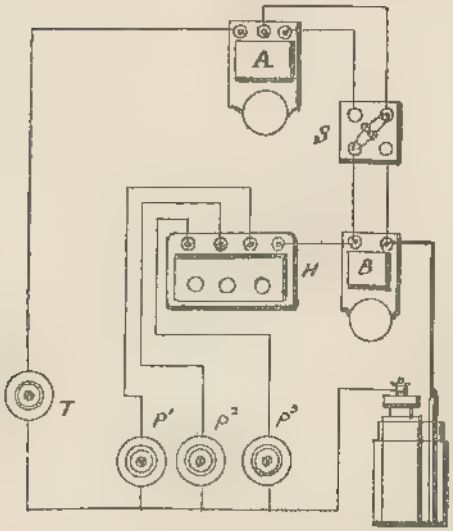


Fig. 123

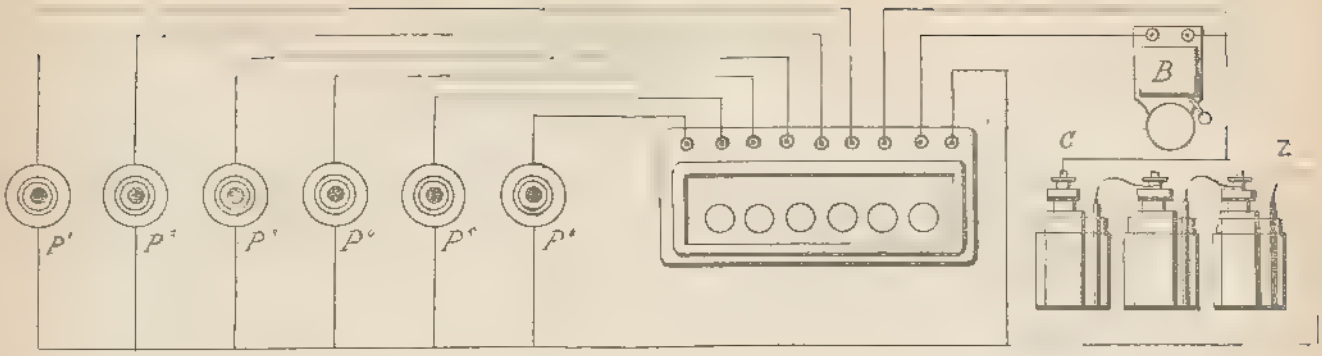


Fig. 124

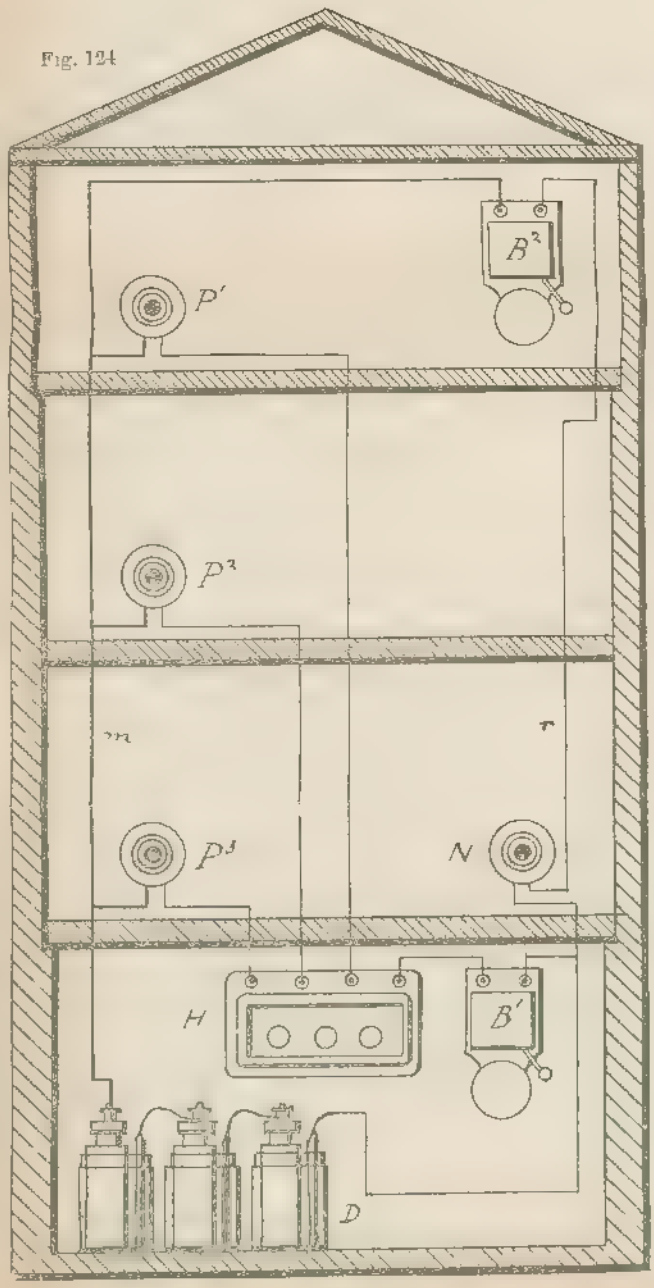
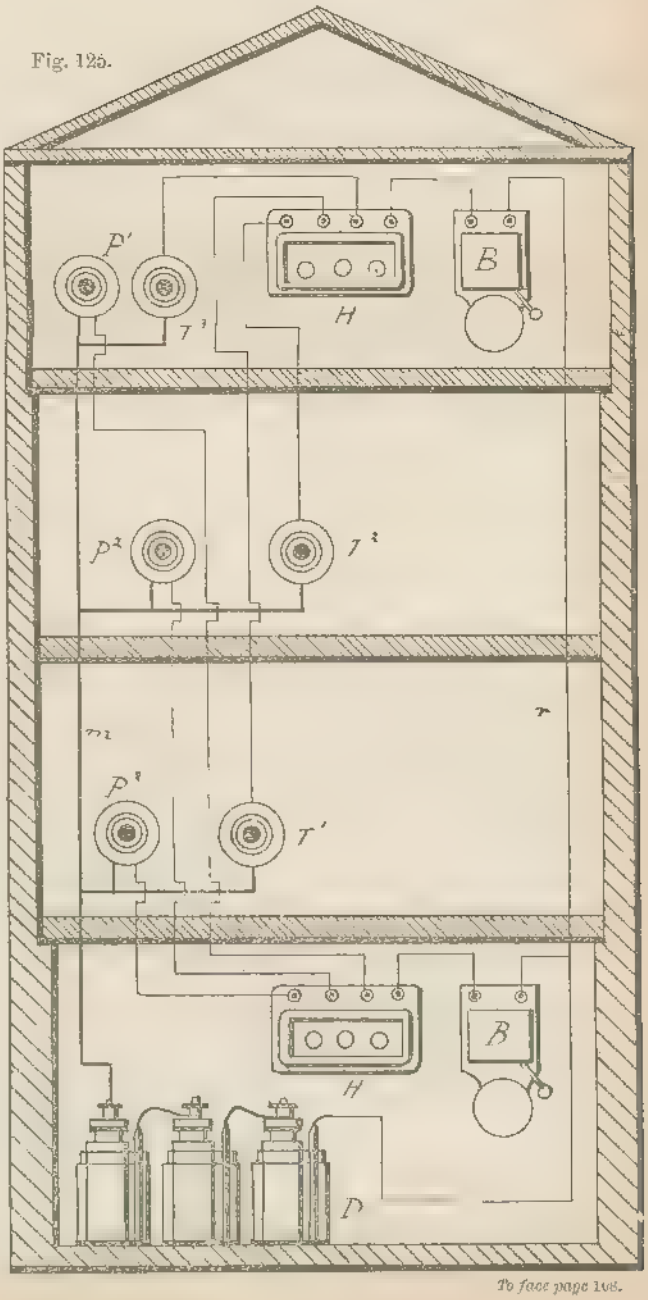


Fig. 125.



To face page 108.

switch S is in the position shown, push T will ring bells A and B, while pushes P^1, P^2, P^3 will ring B only. If now, the arm of the switch is moved over to the other side, the other two contacts are connected, and push T will only ring bell A, while pushes P^1, P^2, P^3 will ring B as before. In Fig. 123 S must be a four point switch, the working of which will be clearly seen from the figure, and the bell A must be of the form shown in Fig. 112, being an ordinary trembling bell, with a third terminal fixed between the original terminals and connected to the screw J on the frame F (see Fig. 41, page 31). When the switch S is in the position shown, and the one in which it would be in the daytime, A is a single-stroke bell in series with B, which thus makes and breaks the circuit for it; but if the arm of the switch is in the opposite position, A is made a trembling bell, and B is cut out of its circuit.

A few diagrams will now be given, showing the most usual methods adopted when fitting up the various apparatus in private houses, hotels, and similar buildings.

Private house circuit; pushes ring downstairs only.—Fig. 124 shows the arrangement generally adopted for a small private house, there being a push in each room to ring downstairs, and one in the hall for the call bell. The push N rings the call bell B^2, while the pushes P^1, P^2, P^3 ring the bell B^1 through the indicator H which is of the simple form, working without a relay. In wiring the house, a main or battery wire *m* (shown darker for distinction) is run up to one of the terminals of the call bell branching off to the pushes P^1, P^2, P^3, as it passes. A separate wire is then run from each of the pushes to the corresponding terminal of the indicator. Another wire *r*, is also brought down from the other terminal of the call bell to the push N, being cut here and then continued on to the other pole of the battery; the current through the indicator also effecting a return to the battery by the lower portion of this wire.

Private house circuit, pushes ring both up and downstairs.—Fig. 125 shows an arrangement used in large private houses

when it is desired to be able to ring upstairs as well as downstairs; two pushes being placed in each room for this purpose. Pushes P^1, P^2, P^3 ring downstairs, while pushes T^1, T^2, T^3 ring upstairs. An indicator H, and bell B, are placed both at the top and bottom of the house, the indicator being of the form described for the previous figure. When wiring, a main wire, *m*, is run (as before) from one pole of the battery to the farthest push, and branches taken off at the most convenient points to the remaining pushes. A separate wire is then run from each of the pushes, those that come from the pushes that are to ring upstairs going to the top indicator, and the others to the bottom one. A return wire, *r*, is also run from the other pole of the battery to the top bell, branching off to the bottom bell as it passes. The front and back doors should preferably ring on to separate bells instead of the ordinary house bell, though, if the expense is objected to, they can, of course, be put on to the indicator. As to which pole of the battery the main wire from the pushes should be attached, provided the insulation is good, it does not matter which: but, as it is best to keep to one way of wiring, it is advisable to conform to the conventional method of attaching it to the positive.

After the building has quite left the painters' and paperhangers' hands, the pushes, bells, and indicators must be fixed, a final test being made with the galvanometer to see that the wires are still in the same condition as when left at the completion of the wiring. When connecting up the pushes, care must be taken not to overturn the screws under which the wires are fixed, for with the majority of pushes as sent out the screws are very small, and generally screwed down hard, consequently when the screws are slacked out and the wires placed under them it is very rarely they will bear the turning necessary to get good contact. If the pushes are hard wood and the screws small, it will amply repay to take out the small ones, re-drill, and put in larger ones. Before cutting off the ends of the wires to connect to the push, a little of the slack should be

worked back into the tube, thus allowing of the connection being made again should it break at any future time. The pushes having all been connected up, the next thing is to fix the bell and indicator. In this country the general practice is to place the bells with the gongs downward, though it is obvious they will work equally well in any position. A bell, however, adjusted for ringing in one position, will, of course, require fresh adjustment if fixed in another. The best place for the bell that works in connection with the indicator is just above the indicator, which, like the bell, must be screwed to a wood block fixed at the time the house was wired.

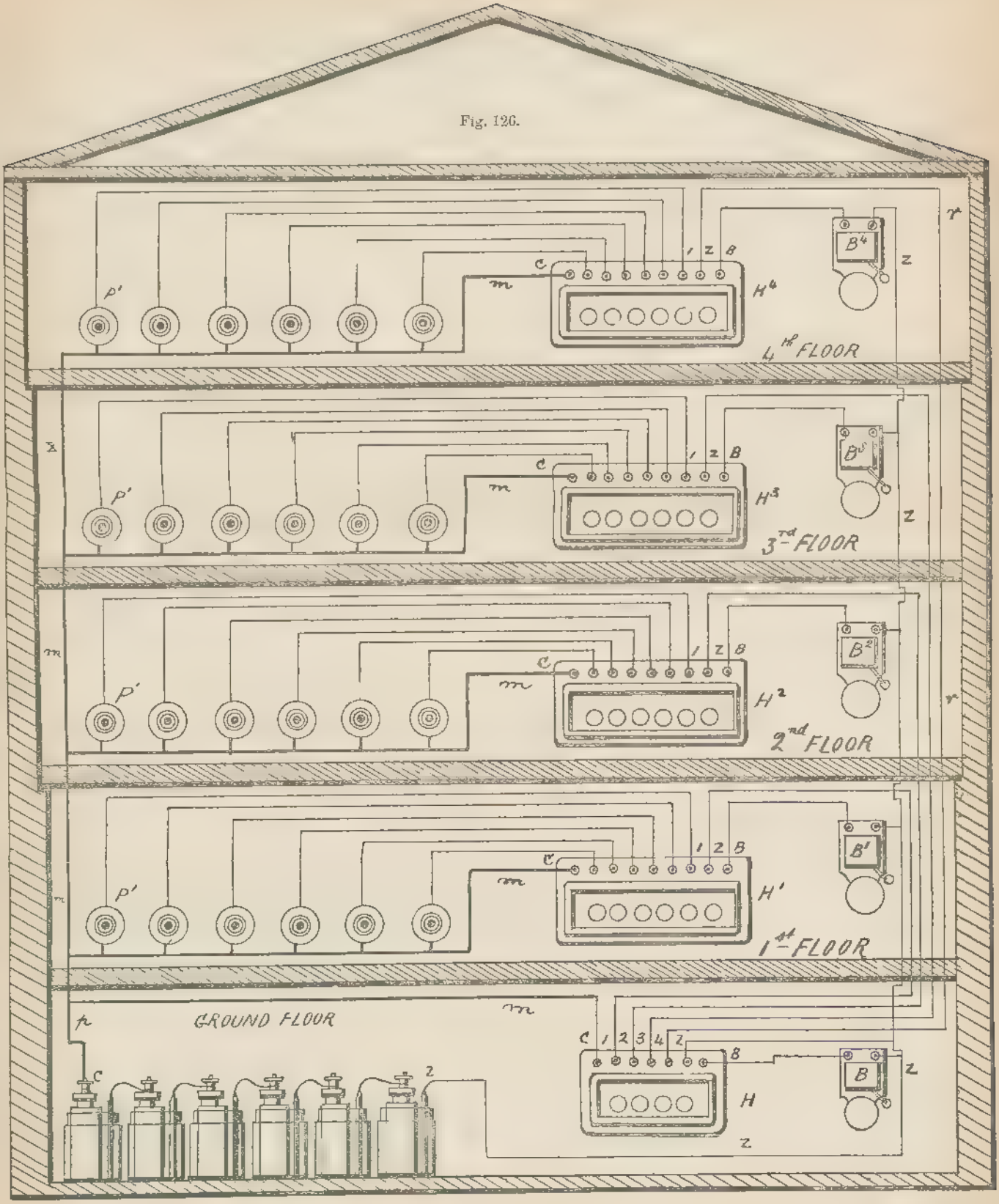
Nothing looks so bad as a bundle of wires all twisted and hanging about loosely, and if there has been any slovenly wiring in a house it will always be found in its most violent form at the indicator. The tubes carrying the wires should either end behind the indicator, and the wires brought over to the top and fastened to their respective terminals, or else, if the battery is in a cupboard near, the tubes should end in the cupboard, and the wires continued on the indicator, tied up into a neat cable. A very good way, however, and the one adopted by the author, is to stop the tubes just beneath the ceiling above the indicator, and then to run a light, flat casing, neatly stapling the wires down inside in the order that they come out of the tubes. This method, besides having a very neat appearance, allows of the various circuits, so far as they branch off into the tubes, being inspected at a glance. Having fixed the indicator bell, and brought all the ends of the wire to the indicator, nothing now remains but to fix the right wires under the different terminals of the indicator. To do this, the battery (having been previously charged) must be put into its proper position and connected up. The assistant must then be sent to the different pushes in succession, going from room to room in a pre-arranged order. At each room he holds the button of the push till he gets the signal to leave go, when he proceeds to the next. Whilst the assistant is pressing the push, the ends of the wires

must be touched in succession on any terminal of the indicator till the bell rings, when the wire that causes the bell to ring must be inserted under that terminal of the indicator which corresponds to the room the assistant is in. A small metal wedge should be included in the fitter's outfit, which (if no assistant is at hand) can be inserted between the springs of the push to close the circuit.

Arrangement of the Circuit for Hotels, &c. For hotels and other large establishments the arrangement shown in Fig. 126 is usually adopted, as being more convenient than using one big indicator, which would in addition necessitate running the whole of the wires to the ground floor. The indicator H on the ground floor merely indicates from which floor the summons has been sent, while the indicators H^1, H^2, H^3, and H^4, placed on the respective floors, indicate the particular room. A bell and indicator are placed on each floor, the indicator being of the form shown in Figs. 65 and 67, in which a relay is employed to close the bell circuit.

Suppose, now, the push P^4 fourth floor is pressed, the circuit through the push is as follows;—Pole C of the battery D, main wire *m*, push P^4 fourth floor, terminal 1 of the indicator H^4, magnet coils of the movement, relay coils, terminal Z of the indicator, wire *r*, terminal 4 of the indicator H, magnet coils of movement, relay coils, terminal Z of the indicator, wire Z, and zinc of the battery. This attracts the armatures of the relays in the indicators H and H^4 causing the bells B and B^4 to ring. The circuit through the bell B^4 is from the main wire *m* to the terminal C of the indicator H^4, relay armature, terminal B of indicator, bell B^4, wire Z, and zinc of the battery. The circuit through bell B is from main wire *m*, terminal C of the indicator H, relay armature, terminal B, wire Z, and zinc of the battery. If Push P^2 third floor is pressed, the same action takes place, only with indicators H^2 and H instead of H^4 and H. The action is, of course, the same for the rest of the pushes, only with different terminals of the indicator.

Fig. 126.


P'
C
1
2
B
m
H⁴
B⁴
Z
Y
4TH FLOOR
X
H³
B³
3RD FLOOR
H²
B²
2ND FLOOR
H'
B'
1ST FLOOR
GROUND FLOOR
p
C
Z
3
4
H
B

It is in a case like this, that a good, substantially made pendulum indicator is so much to be preferred to any kind that requires a shutter or vane to be replaced by the attendant before it can be used again, as with the almost incessant ringing of bells in a large hotel the most careful of servants will repeatedly forget to replace the shutters.

The main wire (shown darker) from the pushes is, in the diagram, taken to the positive pole of the battery, and to this pole, provided the wiring has been done in a substantial manner, it is, as was previously stated, advisable to put it. On referring to the diagram, however, it will be seen that if the main wire *m* is broken let us say, at the point X, the top indicator, with all its dependent pushes, will be disconnected, and the further down the rupture occurs, the more pushes and indicators are cut out, until a rupture in the wire at *p* will cause a break-down in the communication throughout the entire building. Now if, in a badly-wired building, where the insulation of the wires is poor, staples have been injudiciously used, and the situation of the wires is naturally damp, a continual leakage takes place between the wire *m* and all the remaining wires. By the electrolytic action of the current the copper is eaten away from the main wire, the main wire getting thinner and thinner until a jar or variation in the temperature causes the final separation, stopping all communication.

Thus, in the case of a large hotel where the insulation has broken down, and owing to the place being full, it is not convenient to at once remove the faulty wires, the rupture of the main wire may be prevented by simply reversing the battery connections, by this means putting zinc to the main wire. The action on the main wire now ceases, and if a rupture occurs it will be in one of the other wires, which will only affect that push or bell to which it happens to be attached. This continuing of the communication is, of course, only at the expense of the battery, and the faulty wires must be renewed as soon as possible.

The front and back door bells would, of course, be separate from the system of bells from the various rooms, and likewise the communication with the lift next to be described.

Communication with the Lifts. In hotels, and similar buildings, some method of communicating with the lift, by means of which a person can signal to the attendant and receive an intimation that the summons has been heard, and will be attended to, is an absolute necessity. For this purpose nothing can be so readily adapted, or will so fulfil all the necessary conditions, as a good system of electric bells. There are two systems that can be adopted. 1st, that in which naked copper wires and contact springs are used for making connection with the lift-cab; and, 2nd, that in which (with the same object in view) a flexible cable is employed. Of the two, the first has a slight advantage over the second in the matter of cost, as it effects a considerable saving in the quantity of wire used, though much will depend on the selection of the particular system, on the construction of the lift, and the space at one's disposal.

As the difference between the two systems consists merely in the manner in which connection is made between the fixed wires and the movable cab, the connections of the various bells, pushes, &c., will be the same in each, so that a description of the one will refer equally to the other. In either system, then, a push and bell are required on each floor, and a bell and indicator must be fixed in the lift-cab, the indicator having as many "drops" as there are floors. This indicator must be of such design that the ordinary stopping and starting of the lift will not jolt over the vane or release the shutter. For this reason most of the indicators that would be suitable for a house would be useless for this purpose, therefore some such form as shown in Figs. 127 and 128 must be adopted. This is the ordinary telephone indicator, such as is used in telephone exchanges, and consists of an electro-magnet, *e e*, firmly screwed to the frame *f*, to one end of which is pivoted the shutter *s*. Above the magnet *e e* is the armature *a*, pivoted at *g*, and fitted at one

Fig. 127.

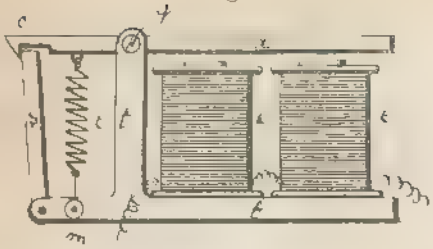


Fig. 128.

Fig. 132.

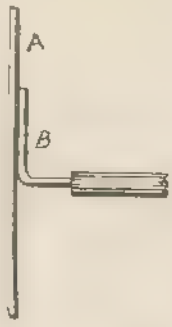
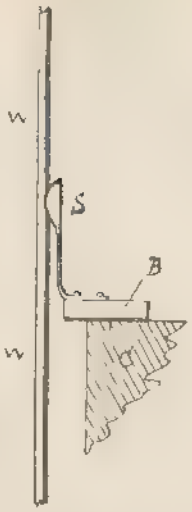


Fig. 131



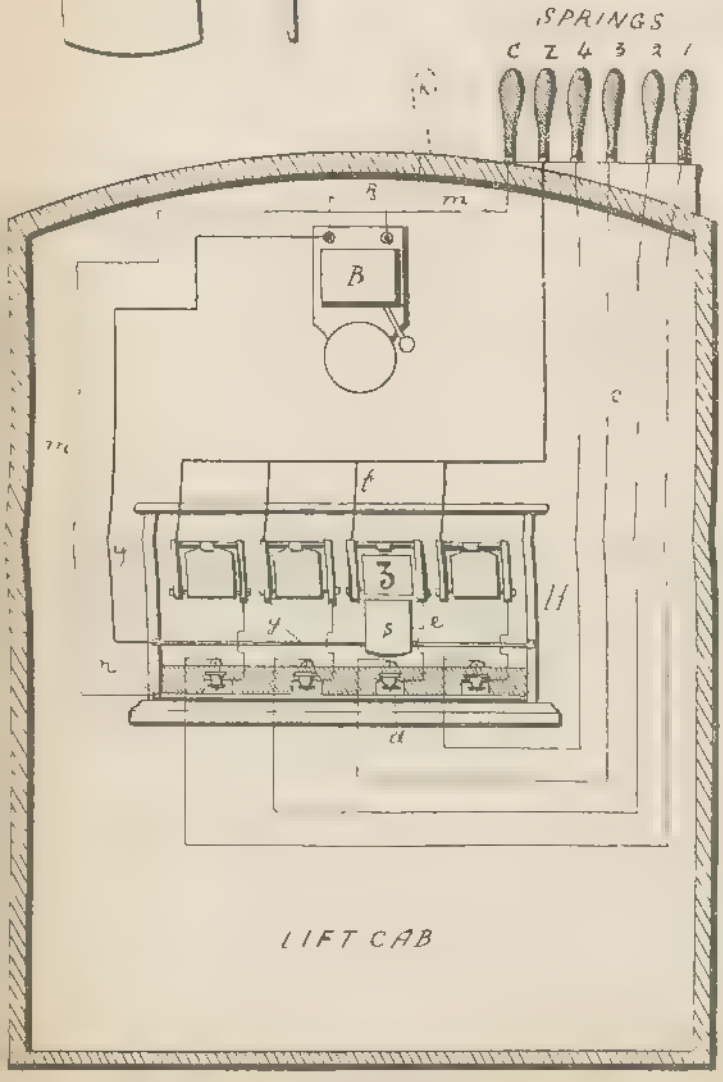


Fig. 129.

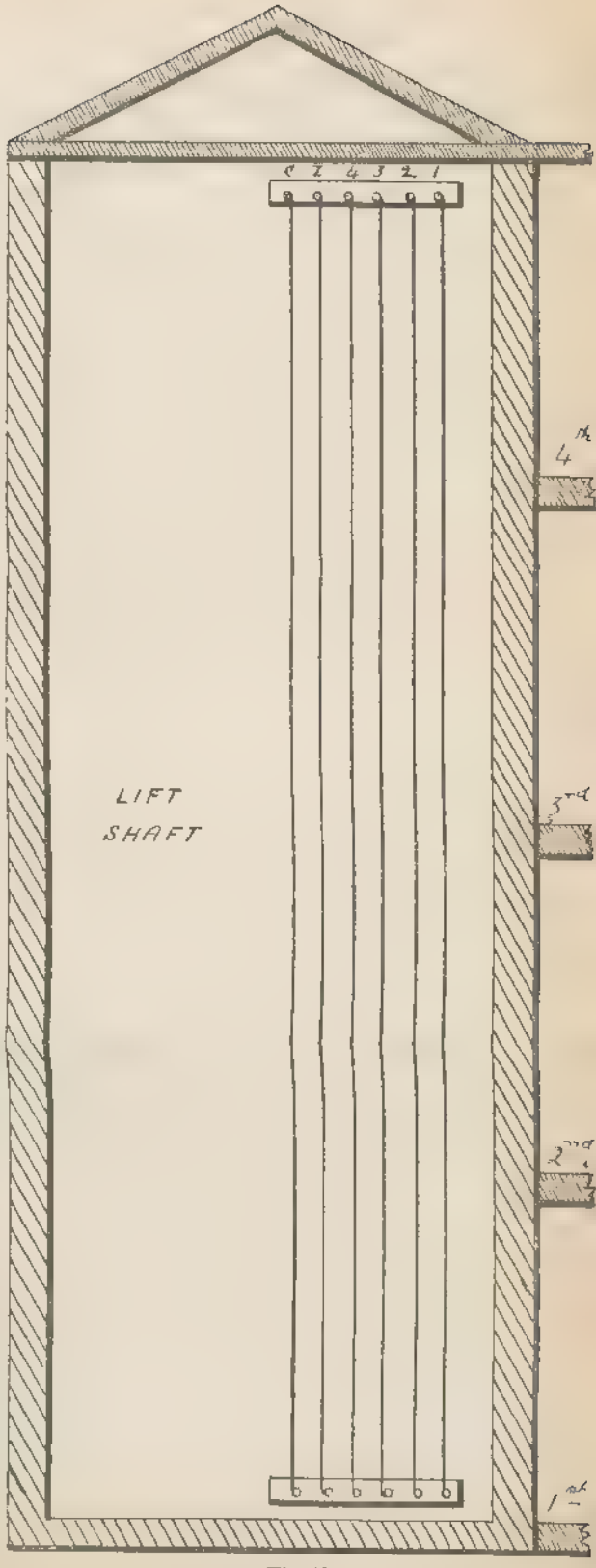


Fig. 130

To face page 114

ed with the catch *c*, which engages with the shutter *s*. When the current passes through the coils of the electro-magnet its armature is attracted against the pressure of the spiral spring *t*, and the catch moves upwards, releasing the shutter, which falls over outward by reason of its being set a little out of the perpendicular, thus disclosing the number printed on the card *h*. The tension of the spiral spring *t*, can be adjusted by the milled screw *w*. Fig. 127 is a side view of the indicator, and Fig. 128 a front elevation with the shutter down. Fig. 121 shows the lift-cab fitted with a bell, and a four-drop indicator of the form just described. Reply keys are also shown at the bottom of the indicator, and likewise the connections to the springs on the top of the cab.

When fitting up the lift on the first-mentioned system a stout oak block (Fig. 130), must be fixed both at the top and bottom of the lift shaft, and the naked copper wires, one for each floor and one for each pole of the battery, stretched from top to bottom, the ends of the wires being fixed by metal pegs, after the manner employed for piano wires. The best method of fixing the pegs and wires is by employing the lift itself. Having got the wires and pegs together, get on top of the lift cab and send it up to the top of the shaft till the top block is well within reach. Mark off on the block six points, leaving two inches between each point and two inches between the outside points and the ends of the block. Now with a gimlet slightly smaller than the metal pegs bore a hole at each of the marks, and drive in a peg, giving each peg two or three turns so as to cause it to bite. Next insert one end of the coil of wire (No. 14 B.W.G. uninsulated) in the hole in the end of the peg, taking two or three turns round it, and then, having seen that the coil is likely to run out freely, start the lift slowly downwards, paying out the wire as it descends, till the bottom block is reached, when the wire must be cut off, and the remaining wires brought down in a similar manner. When all the wires have been brought down, the bottom block must be marked off,

board, and pegs driven in after the manner described for the top block, and the ends of the wires put into the holes in the ends of the pegs. The pegs must then be turned round, tightening up the wires until they begin to stretch, when they will be perfectly tight. Care must be taken that the wires are quite parallel with the traverse of the lift, or the springs will not rub easily. If the lift has been properly erected, it will be sufficient to hang a weight on the bottom of the first wire, after it has been fixed at the top, and a mark made where it hangs, the others being marked off from this point.

The wiring of the lift-shaft having been completed, the next thing is to run the wires from the pushes and bells on the respective floors to the shaft, joining them into the wires that have been stretched from top to bottom. Fig. 134 shows the arrangement of the various apparatus, there being a bell and double contact push on each landing, which pushes were shown in detail in Fig. 17, page 16. When wiring, a wire is first run from the bottom contact of each push to the lift-shaft joining into the wire c that is connected to the positive pole of the battery. A wire is next run from the top contact of each push to one terminal of the bell on the same landing, being continued on from the other terminal to the shaft, and joined into the wire z, which is in connection with the negative pole of the battery. A wire is also run from the spring of each push, and joined into the shaft wire corresponding to the landing from which it comes.

As it is very seldom that a good fixing is to be obtained for the wires in the lift-shaft, it is well, when fixing the shaft wires as described above, to select for this purpose the side of the shaft nearest to the pushes, so as to shorten, as much as possible, the distance through which the wires from the pushes must be run. If, however, space does not permit this, the wall must be "plugged" at such places as it is necessary to obtain a fixing, and the wires stapled to the wooden plugs. In joining the wires from the pushes and bells

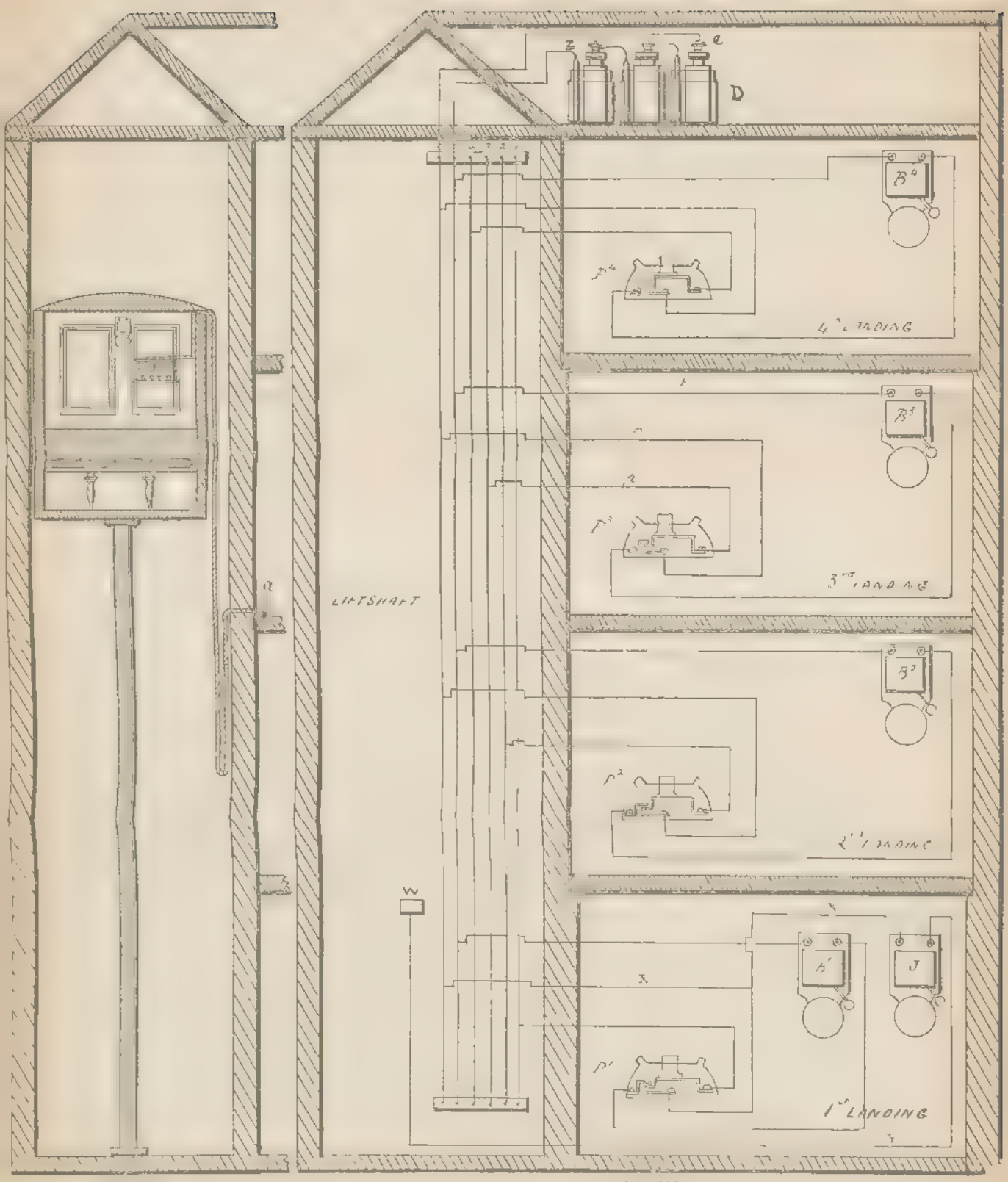


Fig 134

To face page 116

into the shaft wires, the connection must be made at the back of the shaft wires, so that the joints will not interfere with the contact springs, as they move up and down with the lift. Fig. 132, which is a side view, shows how this should be done. The end of the wire B from the push, is turned up and soldered on to the shaft wire A, which, if properly done, should leave no solder on the front of the wire, thus securing a smooth surface for the spring. The wire B must be fixed at the point where it leaves the wall to join the shaft wire, so as to prevent the joint coming to the front, should the wire A have a tendency to twist at any future time.

In order to follow out the circuits, Fig. 129 must be imagined placed in the lift shaft of Fig. 134, the springs (1, 2, 3, 4, *c*, *z*) on the top of the lift-cab coming over their respective shaft wires, with which they would in actual practice maintain a rubbing contact. Pressing either of the pushes, P^1, P^2, P^3, or P^4 will ring the bell B in the lift-cab, and release the shutter of the indicator, corresponding to the floor from which the signal has been sent, while pressing the keys at the bottom of the indicator H will ring the bell fixed on different landings. Suppose, for instance, push P^3 on the third landing is pressed, the circuit closed by pressing in the button, is from the pole C of the battery D, shaft wire C, wire O, bottom contact of push P^3, push-spring, wire *p*, shaft wire 3, spring 3 on top of lift-cab, wire C, key *d* at the bottom of indicator H, top contact, wire *e*, coils of indicator No. 3, framework of movement, wire *f*, spring Z on top of cab, shaft wire Z, and zinc of the battery. This attracts the armature of movement No. 3 of the indicator H, throwing down the shutter, as shown in the figure. The shutter falls on to the copper rod *g*, causing the bell B to ring, the circuit closed being as follows pole C of the battery D, shaft wire *c*, spring *c*, wire *m*, bell B, wire *g*, rod *g*, shutter S, frame of movement 3, wire *f*, spring Z, to zinc of the battery. The bell continues to ring until the shutter is replaced by the attendant, which breaks the bell circuit. He

then presses the key *a* at the bottom of the indicator H, which makes contact with the brass plate *n*, causing the bell B^3 on the third landing to ring; the current flowing from the pole C of the battery to the shaft wire *c*, spring *c*, wire *m*, brass plate *n*, key *d*, wire *e*, spring 3, shaft wire 3, wire *p*, push spring, top contact of push P^3, wire *r*, bell B^3, wire *t*, shaft wire Z, and zinc of the battery. The same action takes place if any of the other pushes are pressed, only with different movements of the indicator H; and different keys must, of course, be used for replying. When the lift cab is down at the bottom of the shaft, the spring *k* placed at the top of the cab makes contact with the brass plate W fixed in the shaft, and puts the bell J (which bell is fixed in the porter's lodge or any other place where the attendant is likely to be when not in the lift, in parallel with the bell B in the cab, so that if a signal is now sent from any of the landings, both bells will ring, the circuit being as follows: Pole C of battery D, shaft wire *c* here it has two paths to the wire *g*, one by wire X, bell J, wire Y, contact W, spring *k*, and wire R, and the other by spring *c*, wire *m*, bell B, there being a common return from both bells by wire *g*, rod *g*, shutter S, movement 3, wire *f*, spring Z, and zinc of the battery.

Fig. 131 is a side elevation showing the contact spring *s* fitted on to the cab *c* by means of the block *b*, and pressing against the shaft-wire *w*. The springs should be set well in towards the wires at the bottom, and must not be too long; otherwise a disagreeable chattering noise will be made as the lift moves up and down. Brass springs are much to be preferred to any description of rollers, as these run round and round and have no tendency to keep the wires bright, thus the contact, after a time, becomes very indifferent. The wires scarcely wear at all, as most of the wear comes on the springs, which can easily be renewed at a trifling cost. The practice of hanging weights on the ends of the shaft wires, instead of fastening them off with the metal pegs, is not advocated, as it has a great tendency to cause the wires to break.

The battery should never be placed at the bottom of the lift shaft, as no matter what construction the lift, there is almost always some leakage, which keeps the place constantly wet. The best position, perhaps, is at the top of the lift shaft, where a beam can generally be found on which to stand it; but if this is not obtainable, it may be placed in some room the wall of which adjoins the shaft, and a hole knocked through for the wires.

Fig. 133 shows a lift shaft and cab fitted with a bell and indicator, connection being made to the cab by means of a flexible cable. The connections of the pushes, bells, &c., for a lift worked on this system are the same as for the one just described, so the lift shaft shown in Fig. 133 can be substituted for the one in Fig. 134. When wiring for a lift on this system all the wires from the various landings must be run to a point (*a*) about half-way up the lift shaft, and joined to one end of the cable. This cable must be composed of a number of small insulated wires, so as to be very flexible; and it is preferable to have each wire composed of a number of strands, as by this means the greatest flexibility is obtained. One end of the cable is suspended at the point *a*, and the other fixed to the top of the cab; being usually supported out a little way by means of a wooden arm. It will be seen, on comparison, that more insulated wire is used in this system, while there is the additional expense of a special cable, the lasting qualities of which are very doubtful.

We will conclude this chapter with an explanation of some of the technical terms used in electric-bell work.

Battery.—The combination of cells which furnish the current of electricity for working the bells, indicators, &c.

Cell.—Each outer jar of the battery, with its two elements and exciting fluids, constitute a cell.

Circuit.—The wires, bells, indicators, batteries, &c., forming the path for the electricity.

Deflection.—The angle or number of degrees through which

the needle of the detector moves during the passage of a current round the coils.

Earth return.—The use of the earth as part of the circuit.

Earth wire. The wire from the bell, battery, &c., leading to the water or gas pipes.

Fault.—Any break or interruption of the circuit by which some of the operations are interfered with.

Line.—The wire joining one station with another.

Line battery. The battery which is used to send the currents to line.

Local battery. The battery placed near the bell or apparatus required to be worked, which continues the ringing of the bell after it has been once started by the current from the line battery.

Local circuit. The circuit through which the current of the local battery flows.

Metallic circuit. The use of another wire for return instead of earth.

To connect up.—To join the bells, indicators, and other apparatus included in the circuit.

To disconnect.—To remove the ends of the wires from the terminals of the instrument, thus cutting it out of the circuit.

To make "earth."—To connect the wire to earth.

A short circuit.—A fault caused by two wires coming together so as to form a shorter path for the current, diverting the whole or greater part of it from its proper course.

To short circuit a cell.—To join the terminals with a piece of wire.

To short circuit an instrument.—To join the terminals of the bell, &c., with a piece of wire.

CHAPTER VII.

THE DETECTOR, AND LOCALISING FAULTS.

Both for localising faults and in order to ascertain the condition of the batteries, a small galvanometer—technically called a "detector"—should be provided. Figs. 135 and 136 (which are full size) show the most usual form of this instrument, Fig. 135 being a front elevation, and Fig. 136 a back elevation; the back part of the case having been removed at the hinges. As will be seen from the drawing, it consists of a mahogany box *a*, into the front of which a circular aperture has been cut. Inside this box is fastened the brass plate *b*, one side of which is silvered and marked with a scale, the plate being so fixed that the scale is visible through the aperture. To the back of the brass plate are fixed the two brass bobbins *c c*, on which the wire has been previously wound, two bobbins being generally employed in preference to one, as this method offers greater facilities of construction. The instrument has two needles—the smaller one working inside the brass bobbins, its lower or N. end being weighted for the purpose of bringing the needle to zero, the weight being merely such as will suffice to counteract the "dip" and keep the needle vertical. The other needle, which is lighter and longer, is placed in front of the dial, and immediately indicates the passage of a current through the coils of the detector by being deflected over the scale either to the right or left, according to the direction of the current. Both needles are carried by a common spindle, the front end of which is supported by the bar screwed on to the front of the dial, and the back by the screw *d* seen between the bobbins in

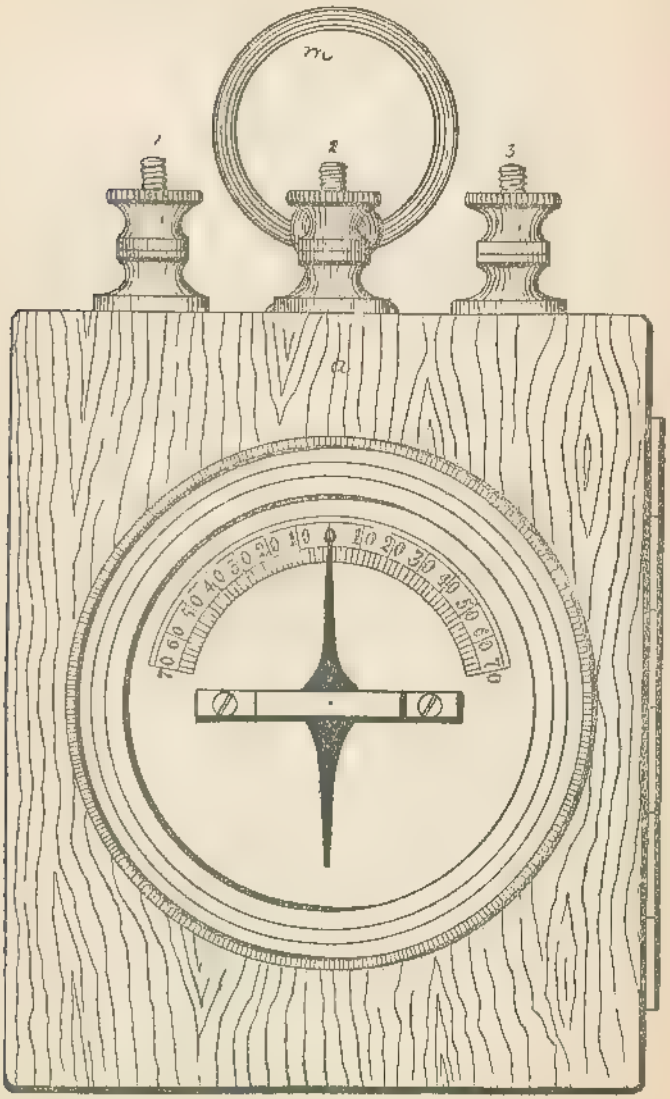


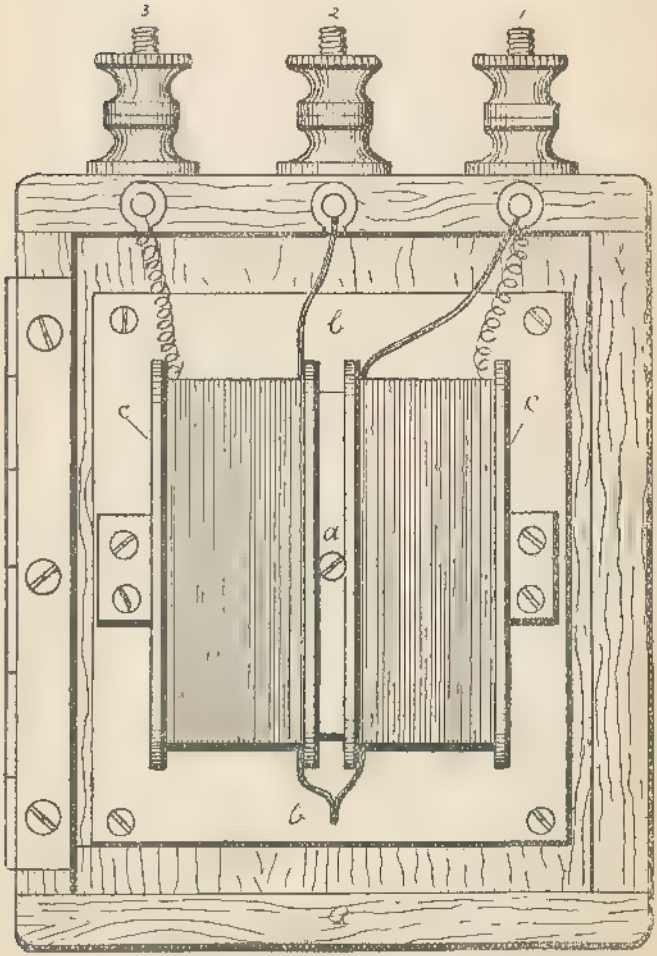
Fig. 135.

Fig. 136, the pivots in the more expensive instruments being jewelled.

The instrument is wound for quantity and intensity as it is usually called, the quantity or shunt coil consisting of a single layer of thick wire having a low resistance, generally some decimal of an ohm, and the intensity or long coil having a number of layers of very fine wire with a resistance of 150 to 200 ohms. The ends of these coils are connected to the three brass terminals on the top of the case, so that terminals 1 and 2 will give the quantity coils, and terminals 1 and 3 the intensity coils. A brass ring *m* is also fixed to the top of the case for convenience in carrying it about.

As, however, the scale of the detector is frequently hidden by the brass rim that holds the glass when standing on the ground, the scale is sometimes marked on the lower half of the dial, or a mirror is attached, which can be set at any angle so that the scale can be easily seen when standing in almost any position. Detectors can also be obtained with the intensity coil, provided with a shunt of one-tenth its resistance, so that when the shunt is put in circuit (which is done by means of a switch), one-tenth of the current only passes through the intensity coils, which greatly increases the utility of the instrument. The dial of the detector is graduated in degrees, and it may be as well to point out that the graduations on the scale are not proportional to the current flowing. It is fairly accurate up to 20°; but as the needle moves further and further from parallelism with the coils, the effect of the current gets less and less, until at right angles, or 90°, it is practically *nil*. As detectors vary considerably, no standard table of deflections for a certain current strength can be given; but each detector should be coupled up to a good cell of the different sizes, and the deflection noted for future use, the *quantity* coils being used for this test as a very bad cell will give a good deflection on the fine-wire coils. A detector of the form shown in the drawing, and having the quantity coils wound outside the

Fig. 136.

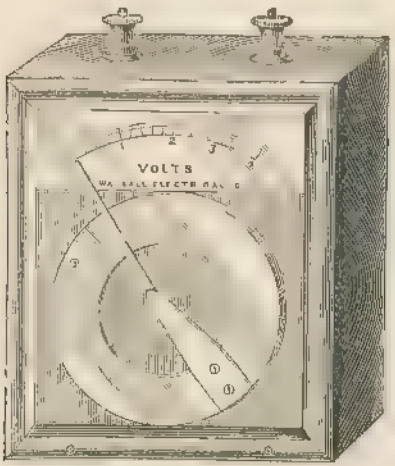


intensity, the resistance of the quantity being ·3 ohm, and the intensity 120 ohms, will give, roughly, on a newly set-up

Leclanché (porous pot form), No. 1, 26°; No. 2, 45°; No. 3, 60; the deflection on the intensity coils being, of course, about the same for all sizes.

In addition to the detector, a low resistance voltmeter will be found very convenient. The condition of the cells can be better ascertained by its use as it shows at once the E.M.F. of each cell. A form of this voltmeter as manufactured by the Wallsall Electrical Co. is shown in Fig. 137. As will be seen

Fig. 137.



from the figure, the instrument is "direct reading," the scale being graduated from one to four volts in fifths of a volt. It is also to be obtained with the scale graduated from one to three volts advancing by tenths of a volt and this instrument is better suited to the purpose for which the bell-fitter will require it. When a newly set up Leclanché cell is coupled up to the voltmeter the needle will indicate an E.M.F. of 1·6 volts, but if the cell has been at work a long time and is nearly exhausted its E.M.F. will be found to have considerably fallen, the deflection

being low from .8 to 3 according to the state of exhaustion of the cell.

The length of time that the electric bells in a building will run without a "fault" may generally be taken as a pretty good proof as to the quality of the workmanship and apparatus. If good apparatus has been employed, and the wiring done in a thoroughly substantial manner, the bells should run for a year to eighteen months without the slightest attention, and the only expense then should be a few pence for recharging the battery. But if with a view to cheapness inferior apparatus and badly-insulated wire is used, there will be a continual occurrence of faults throughout the entire building, and the bells will be nothing but an intolerable nuisance.

We will now turn our attention to some of the defects that may be looked for in the various apparatus.

Pushes will often give trouble from deterioration of the connection between the ends of the wires and the contact springs. If the wire used is not "tinned" the ends quickly oxidise, and unless they have been well inserted between the contact spring and the washer on the screw, the connection rapidly deteriorates, finally introducing so much resistance that the bell will not ring through it. In ship wiring the deterioration of these connections are much more rapid, and it is always advisable in this case to secure the ends of the wires to the springs by soldering. In the best pushes the springs are of German silver or aluminium, the tips, at the point where they make contact with one another, being faced with platinum. Pushes thus constructed are very free from defects, but German silver or other rubbish is frequently substituted for the platinum, or very often nothing is used at the point of contact but the surface of the spring itself. Trouble, therefore, often arises from insufficient contact between the springs themselves. The contacts may easily be tested to find out whether they are really platinum or not, by applying by means of a glass rod some nitric acid to the contact. If the metal bubbles up it is not platinum, but probably German silver,

as platinum is not attacked by nitric acid. Sometimes a short circuit will occur between the two wires that run to the push, either from the insulation of the wires having been stripped too far back, or from the edge of the zinc tube, where it ends in the block at the back of the push, not having been turned over properly; the sharp edge of the tube penetrating the covering. When the hole in the back of the push is of insufficient size to permit of the two wires with their insulating covering being brought through, it is *always* better to enlarge the hole, in preference to the practice sometimes adopted of stripping the insulation of one of the wires right back, and bringing the two wires through, the one bared of its insulation.

Bells, unless the workmanship is very bad, rarely give much trouble. They are liable, however, to get out of adjustment, and the ringing of the best bells can be spoiled for want of knowing how to adjust them properly. Bells in which the separate parts are not mounted on a wooden frame independently of the wooden base should never be used, as owing to the warping of the base they will never keep the same adjustment for any length of time. As in pushes, German silver is frequently substituted for platinum in the contacts, and if a bell rings badly and cleaning the contacts sets it right for a little while, some metal other than platinum may be suspected of being used. This should be tested as was advised in the case of the push springs, care being taken to wipe off the acid should the contact be found to be platinum. Bells in which the bobbins are of metal instead of wood will frequently give trouble by the ends of the wires at the point where they leave the coil coming in contact with the cheeks of the bobbin, thus short circuiting the bell. In the cheaper bells where an iron base is used either one or both of the terminals are insulated from the iron frame. These terminals owing to the vibration of the movement, sometimes work to one side and touch the frame, thus cutting the movement out of the circuit. Very often when a bell rings at one time and not at another, it will be found on inspecting the bell that

detector, using the fine wire coils. A short length of wire is next joined to the other terminal of the detector. With a knife the covering of the wire to be tested is removed, care being taken not to nick the wire or remove more of the insulation than is necessary to expose the copper, and the wire from the detector touched on the exposed place. If a movement of the needle of the detector is obtained the wire is intact between the place tested and the end of the line that is put to earth, but if no deflection is obtained the wire is broken in this part. Care must be taken to see that a good earth connection is made by the iron rod. If the circuit is complete so far, we must (having first well insulated the bared place on the wire with Chatterton's compound) proceed to the next convenient place. Here we go through the same operation, and if the circuit is complete proceed to the next, and so on until no deflection of the needle of the detector is obtained, when the break will be between this place and the one last tried, at which the detector showed a deflection. From this place we then work backwards till the fault is found. It must be borne in mind, however, that this test is no good if the insulation of the line is faulty, and it makes "earth" anywhere, which should be previously ascertained.

If the fault was a leak to earth instead of a break, we must, before testing, remove the ends of the wires from the instruments at both ends of the line. We next proceed to the most accessible place in the wire (preferably where we know there is a joint), and, having arranged our detector as in the previous case, we cut the line wire and touch the end of the wire from the detector, first on one end of the line and then on the other; the part which gives a deflection being the faulty wire. We then try at different places in the faulty part till we succeed in localising the fault.

When a fitter is called to a fault in any building, he should touch nothing until he is pretty sure what is the cause of, or in what direction the fault lies. More especially should this be attended to in regard to the wires. He should not touch the

wires until he is perfectly sure that the fault is in the wiring, for if the wires are cut here and there, as may be necessary when tracing a fault, it is seldom that the bare places, when bound up, will show the same insulation that they did before. He should first gain all information as to how and when the bells ceased to ring, or whatever the fault may be. If the bell rings, and the indicator does not work, he should not necessarily conclude that the fault lies with the indicator, and forthwith, fiercely attack the indicator with screw-driver and pliers, only to find, after he has taken the thing to pieces, that it was all right, and that the fault was really in the battery, which was nearly exhausted. The most frequent cause of the bells not ringing, is from the battery having run down. When a fitter is called to a fault, and is told that none of the bells will ring, he may generally suspect the battery of being exhausted. He should first inspect the battery, joining up the cells to the quantity coils of his detector, and comparing the deflection with that obtained from a good cell, and should it be found exhausted, it must be recharged, directions for which are given in Chapter IV., on batteries. A break in the main wire close to the battery would cause a similar fault, and if the battery is found all right, this wire should be inspected. If the bell rings feebly while the battery is in good condition, a bad joint may be suspected in one of the wires. Faults occur in the pushes, and especially if the springs are not fitted with platinum contacts, and should the bell ring at one time, while it does not at another, dirty contacts will generally be found in the push; but if push seems all right, the fault may be in the bell. If the bell rings continuously, a contact between two wires may be suspected, or the push spring may have stuck. Pulls, and especially the one at the tradesmen's entrance, are very likely to cause the bell to ring continuously, as the spiral spring loses its set, and after a time does not move the disc (see Fig. 22, page 18) back clear of the springs, thus keeping the circuit closed.

When a fitter is out on "detective duty," he will rarely require his heavier tools, and the following articles (which will go easily into a small bag), he will find the most convenient to take with him:

1 pair of taper nose-cutting pliers.
1 small screw-driver.
1 4-inch smooth flat file.
1 small rat-tail file.
1 bradawl.
1 small hammer.
3 spare zincs (one of each size).
A packet of sal-ammoniac.
A small box of staples.
A sheet of emery cloth.
A few binding screws.
A small coil of No. 20 paraffin wire.

As a parting word to electric bell fitters, and all who have anything to do with electric bells, I say, *Be thorough*. Do not leave a piece of work with the words, "Oh! that will do," as nothing is so fatal to success in electrical work as apparatus erected in a manner that will just *do*. If a fault occurs, put it right at once, and put it right thoroughly, not merely patching it up, thinking to put it right at some future time. If you are screwing up the adjustment screw of a bell, remember you are working at a bell; and if you are adjusting an indicator, remember you are at work on an indicator, and not a 100 horse-power Galloway engine.

CHAPTER VIII.

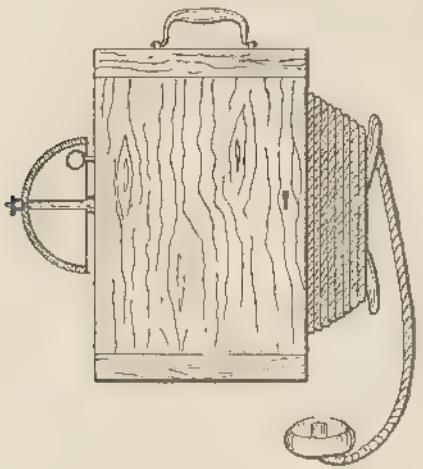
PORTABLE SETS.

When only temporary communication is desired between two places, what is known as a "portable set," will be found very convenient. These sets consist of a battery, bell and push, the battery generally being enclosed in a wooden case, to the outside of which is fixed the bell, connection being made between the bell and push by means of flexible wires. Portable sets are now to be found in innumerable shapes and designs, each manufacturer having his own arrangement. In order to aid the reader in the selection of a good portable set, we will just glance at a few of the more important points that should be looked to when making a purchase: 1st. The battery should be either a "sealed" or a "dry" one. 2nd. The bell should give out a loud *clear* sound. 3rd. There should be suitable means of rapidly coiling and uncoiling the flexible wire from the push. 4th. The set should have a neat appearance, and not be of an inconvenient size or shape, and 5th. If the set is for the use of an invalid—such as to be used for summoning the nurse—the push or pressel should be so constructed as to work with the slightest pressure

Portable sets that do not fulfil the first condition, i. e., contain a battery that is an ordinary or else a so-called sealed Leclanché, have the objection that they are confined to one position, and moreover, if accidentally upset, a by no means infrequent occurrence, the contents are precipitated on any articles that may happen to be standing near it. Trouble also arises in a set with a battery of this form from the solution during

transportation, splashing on to the terminals, and destroying the connection. The "circular" bell, except in the cheaper forms, is the one usually employed in portable sets, the hammer of the bell striking on a lug fixed on the inside of the gong. Sometimes, owing to bad construction or design, the gong gives out, instead of a clear musical sound, an unpleasant tapping one, and a set with a bell of this kind should be rejected, as it has not the penetrating effect of the proper bell. Bell sets that do not fulfil the third condition, have an untidy appearance, and the wire, owing to the want of something to wind it on when not in use, rapidly gets into tangles and kinks, which generally end in causing the wire to break at the kink. The wire employed is a twin wire, each wire, which is composed of a number of small strands, being insulated with silk. It is

Fig. 138.

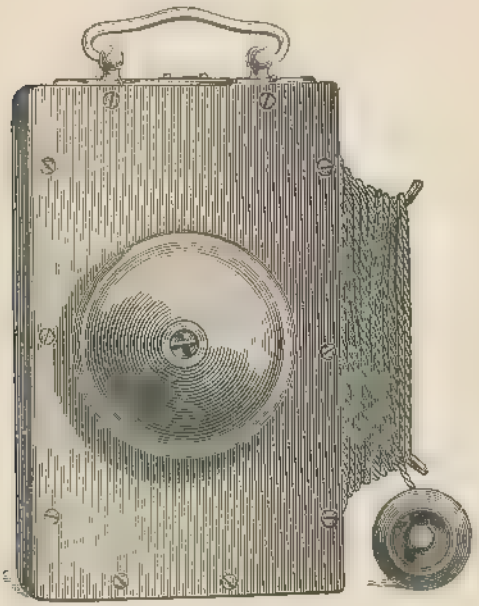


important that the set should have a good appearance, as, from the nature of its use, it is more exposed to view than the ordinary electric bell, which is generally fixed in an out-of the-way place in the kitchen or corridor adjoining it.

Fig. 138 shows a form of the portable set. The gong of the bell is mounted on the outside of the case, the movement, which is of special design, being placed inside. The battery is a No. 2 sealed Leclanché, and the flexible wire with push attached is, when not in use, coiled round the two prongs seen at the back of the case. At the top is a handle, by means of which it is carried from place to place.

In the Jensen portable set a church bell shape Jensen bell is employed, the bell being mounted on the top of the polished

Fig. 139.



mahogany case and supported off from the woodwork by four brass arms. The battery is a Jensen dry cell.

Fig. 139 shows the "Brighton" portable set. In this set a flat, polished walnut case is used, on which is mounted a

rimmed bell of special design. On one side of the case are two brass fittings, round which is coiled 30 feet of flexible wire, with an invalid pressel attached to the end of it. The battery employed is a Gassner dry cell, which is so arranged that it can be easily taken out and replaced, the two elements making contact with two platinum pointed springs. On the top is a brass handle for convenience in carrying it about. The bell will ring in any position, and the battery, owing to the pressure of the springs, is entirely prevented from jolting about. The set can thus be packed in with other things without any danger of their being spoilt by liquids leaking out, an objection which every set is open to that contains a "wet" cell.

Fig. 140

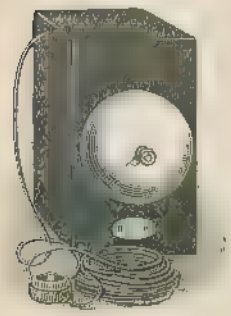


Fig. 141.

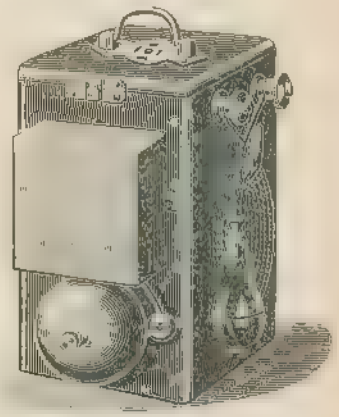


Fig. 140 shows the Judson portable set, its chief speciality being its battery, which is of the corrugated carbon form, shown on p. 64.

The electric trumpet of Messrs. Einswanger & Co., as described on p. 45, is also to be obtained made up into a portable form. In places where a loud noise is not desired it is well adapted, as it can be easily adjusted so as to give out a subdued

sound. Fig. 141 shows a form of the portable electric bell set as manufactured by Messrs. Baswanger & Co.

Portable sets, provided a good form of cell is used, require but little attention to keep them in order. A bad cell, however, owing to creeping of the salts and splashing of the liquids, will cause a lot of trouble, and nothing is equal to the dry cell for portable sets. The insulation of the flexible wires also frequently frays off, and as the two wires are generally twisted round one another, or else bound together, it causes a short circuit, cutting out the push. Thirty feet is the usual length of wire supplied with a portable set, though it is obvious that more can be added if required. If much more wire is put on, however, another cell must be added to the battery, as, owing to the increase of the resistance of the circuit caused by the addition of more wire, the ringing of the bell becomes very feeble.

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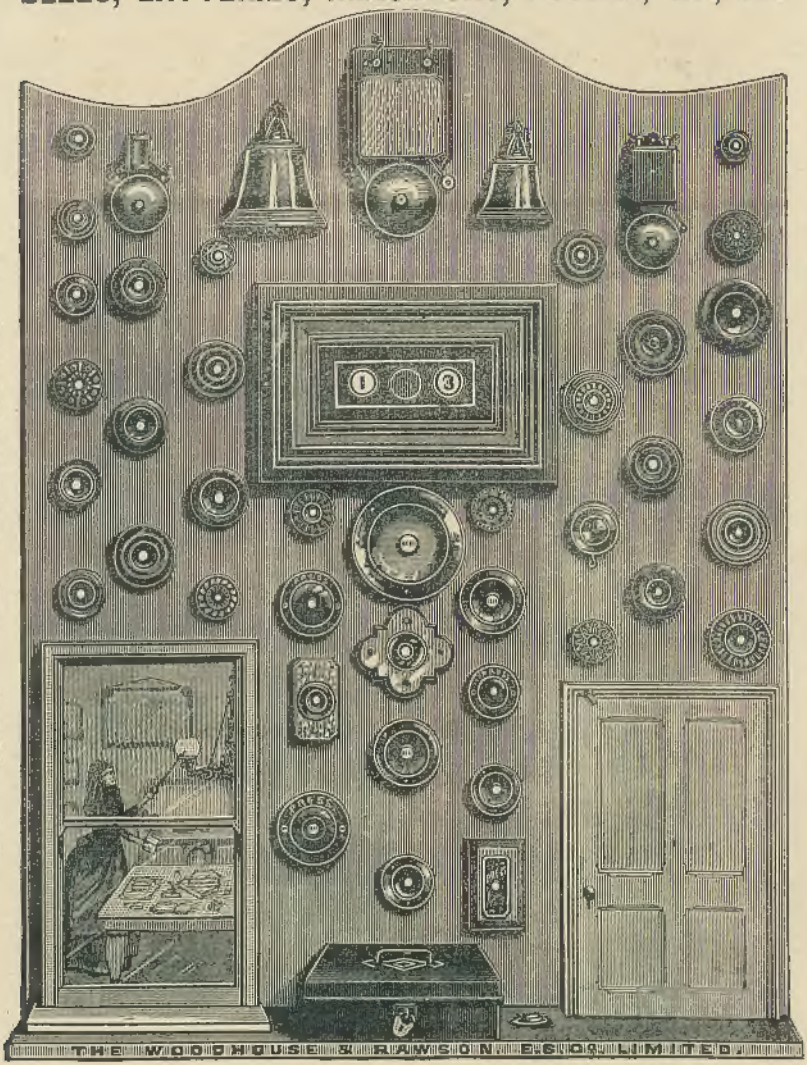

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